CROP FARM DEVELOPMENT IN THE BRAZILIAN "CERRADO" REGION: AN *EX-ANTE* EVALUATION

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Declaration

I declare that this thesis has been composed by myself and that the research reported therein has been conducted by myself unless otherwise indicated.

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Abstract

Abstract of a thesis submitted in fulfilment of the requirements of the Degree of PhD

CROP FARM DEVELOPMENT IN THE BRAZILIAN "CERRADO" REGION:
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by

Rui F. Veloso

Natural resource use planning in an area such as the "Cerrado" region in the Midwest of Brazil is a challenge. Any planning framework for analysing investment opportunities in such a region must emphasize sustainable development. This implies a shift from the traditional single agricultural expansion objective approach, to a multiple objective approach such as that described in this thesis.

The main objective of this study was to develop an appropriate planning framework for quantifying the effects of new crop farm development proposals for the "Cerrado" region, from a multiple objective perspective. Its practical implementation depends on the following: the generation of specific experimental data on rice, maize, wheat and soybean crops and reliable climate and soils data to calibrate corresponding crop models that are incorporated into a planning framework; the development of experiences concerning environmental quality and social impact analysis by Brazilian researchers; and training of planning framework users for the enlightenment of policy makers.

The study was carried out from the point of view of systems theory, and the chosen research approach integrates a set of different modelling techniques within the developed planning framework. The application of a such planning framework for the Paracatu "Planicie" area was orientated to the final selection (among nine alternatives) of the most appropriate farming system for adoption. However, by manipulating the models which were integrated into the planning framework, and parameters and data related to prices, crop yields, farm sizes, interest rates, credit and others, a range of policy types can be represented and their effects assessed.

The results presented illustrate the potential of the planning framework developed here, as a policy analysis tool for farm development. In the conclusions, some insight is provided into aspects concerning the incorporation of this planning framework into a comprehensive decision support system.

Keywords: ex-ante analysis, savanna resource development, farm development and regional planning, simulation crop model, mathematical programming model, goal programming, farm level, regional level.

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(1)International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT).
(2)"Empresa Brasileira de Pequisa Agropecuaria" (EMBRAPA).

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1 Introduction

1.1 Study Proposal:

Some large commercial farms have been established in the "Cerrado" region due to a large amounts of subsidised capital being made available for special projects, (Franz et al 1985). However, the appropriate use of technological packages indicated by research stations, on a large number of other Brazilian farms, has been limited by factors which include the difficulties the farmers face in borrowing capital for basic investments (such as: adequate soil fertility correction and soil conservation measures). This has consequently resulted in lower yields at the national level.

Analysis of some of the technologies recommended by CPAC/EMBRAPA[1] for each enterprise at the farm level, did not indicate all the possible implications and results. Factors which have been excluded from analysis include economic, environmental and social aspects and their interactions with the technological recommendations.

Given that capital is a scarce resource, its use must be rationalised to ensure the effectiveness, of agricultural development, in the "Cerrado" region. Thus, research should be carried out in an inter-disciplinary manner to explore investment alternatives available to farmers.

The proposed study will analyse different sets of producer decisions aimed at developing an optimal investment schedule while at the same time maintaining adequate working capital for ongoing activities and living expenses. Factors which will be considered are:

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[1]Centro de Pesquisa Agropecuaria dos Cerrados / Empresa Brasileira de Pesquisa Agropecuaria (CPAC/EMBRAPA).

i. Different quantities of resources owned by farmer.

ii. Alternative interest rates for agricultural credit.

iii. Different sets of machinery.

iv. Different technological packages.

v. Different yields and prices of inputs and outputs.

vi. Different combinations of activities.

vii. Different needs and objectives of farmers.

Using the systems approach it is expected that the study will be able to determine the highest level of interest on agricultural credit which a farmer can sustain while maintaining various enterprises on a continuing basis. Furthermore, specific analysis will be carried out to examine the advantages of some technological recommendations: in other words, the concept is to find what the feasibility and relative profitability of alternative systems are.

1.2 Objectives:

The general objective of the study is to develop flexible computer models that can be used to analyse capital investment strategies for a crop farm in the "Cerrado" region. Basically, the study will emphasize:

* Soil acidity and fertility correction technologies;

* Utilisation of new areas for crops each year;

* Alternative farm activities, considering adequate rotations and the risks related to their yields and market prices;

* Rural credit policies for investment at the farm level; and

* The assessment, in economic and social terms, of the minimum size for a new commercial farm in the "Cerrado" region. This will require an analysis at an aggregate level which will be described in the methodology of this study.

A secondary objective of the study is to build the computer models in such a way that they can be included within an information system to assist researchers and analysts involved in <u>ex-ante</u> and <u>ex-nunc</u> (monitoring) appraisals of development projects in the "Cerrado".

1.3 Hypotheses:

The study is established to examine the following hypotheses, which will be discussed during the system analysis or modelling development stage:

* Capital allocation efficiency (i e. in terms of the amount of output produced per unit of capital input) is a fundamental aspect of the development of the "Cerrado" region.

* The accomplishment of targets for crop farm development in the "Cerrado" region is dependent on the increases in productivity and on the credit policies adopted for the region.

* Any increase in crop productivity (i e.

production/hectare) is heavily dependent on the use of soil fertility correction technologies, selected varieties and the local weather.

* The crop yields and the commodity (rice, maize, wheat and soybean) prices are not correlated.

* The services which are provided by a cooperative or contractor can perfectly suit the farmers' needs in terms of mechanisation without increasing post-harvest losses or any other losses.

The following issues will then be considered in the study:

* In considering alternative activities for a farmer at the "Planicie" area of Paracatu District, what is the minimum size (in economic terms) for his new commercial farm in the long-term?

* What alternative crops and rotations are potentially suitable in such place?

* In contracting hiring or share-owning a combine harvester and more powerful tractors, the farmer may be choosing a better option (in economic terms) than buying them.

* Is subsidised investment credit an important incentive, and - for the "Cerrado" region - a necessary condition for increasing the adoption of soil management and correction technologies? This consideration will examine the options of lower real interest rates.

* Delaying interest payments and capitalising interest payments in early years into the loan.

1.4 Outline of Thesis

This thesis is concerned with crop farm development in the "Cerrado" region, and with the effects of such development on rural development. A principal objective of the study was to develop a planning framework through which it was possible to analyse investment strategies. The thesis consists of three parts.

Part one presents the background to the study. In Chapter 1 the proposal, the objectives and hypotheses of this study are presented. Chapter 2 present an overview of Brazilian agriculture and its problems. Chapter 3 describes agricultural aspects of the "Regiao Geoeconomica de Brasilia" (RGE) and the case study area in the Paracatu district, in Minas Gerais. Chapter 4 attempts to conceptualise the problem for research and presents the conceptual modelling framework chosen for the present study, (see Figure 4.1).

Part two consists of three chapters involving the modelling development. Chapter 5 outlines the IBSNAT[2] crop models and validation of these within the local area. It attempts adjustments of four crop models (rice, maize, wheat and soybean) for Paracatu conditions to permit more effective prediction based on climate and soils data bases. Results generated by such crop models are incorporated into a whole farm model because no comprehensive field or experimental yield data are available. This is described in Chapter 6. Once the whole farm model is developed, it is used to generate alternative farm systems which are then incorporated in a regional level model described in Chapter 7. Such a

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[2]The International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT).

regional level model adopts a multiple objective approach considered appropriate to deal with farm planning problems in a rural development context.

Part three of the thesis attempts to evaluate the farm planning framework developed and applied for the Paracatu "Planicie" area. In Chapter 8 a discussion of the modelling work and results produced, is presented. The results of regional planning, implications of projected farm systems under different policies for regional development, the effectiveness of the modelling results and the limitations of the present study and future development are then discussed. Finally, Chapter 9 presents the conclusions of the study, including an examination of the applicability to Brazilian policy makers of the planning framework developed in this thesis.

Chapter 2 Brazilian Agriculture

2.1 General Background

2.2 Development Projects

2.3 Agricultural Development

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2.4.1 Rural credit administration

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2 Brazilian Agriculture

2.1 General Background

The "Federative" Republic of Brazil occupies a unique position in the Western Hemisphere. Its population constitutes one third and its area almost half that of South America. In territorial extension - 8.51 million km^2 - Brazil is the fifth largest country in the world, coming after the Soviet Union, Canada, China and the United States of America (USA).

The greater part of the country consists of highlands which fall sharply to the Atlantic shore and gradually to the west, forming an extensive plain supporting the vast rain forests of the Amazon. Geographic regions, distinguished by variations in topography, climate, ecology and economic conditions, are usually designated as the North, the Northeast, the Southeast, the South, and the Central-West.

In the past, heavy reliance on export crops created economic problems. During the latter half of the nineteenth century and the first half on the twentieth, coffee was the principal export crop, and its producers constituted a powerful group that persuaded the government to subsidize production. During the 1930s, however, the industrial sector began to grow, and between 1964 and 1974 economic growth reached unprecedented proportions. Exports, including manufactured goods, had increased as had the production of such commodities as steel, automobiles, and textiles. As its economic power grew, the country's international influence was increasing in the Western Hemisphere, and in international organizations concerned with global problems of finance, trade, and the environment.

Varied soil and climatic conditions result in an enormous variety of predominantly tropical plant and animal life. In the mid-1980s large-scale exploitation of Brazil's mineral wealth remained at an early stage of development. Brazil has substantial and widely distributed reserves of most of the important metal ores, and it may have the world's largest reserves of iron, tin, manganese, and others.

A tropical country crossed by the equator, Brazil is for the most part characterized by high temperatures and moderate to heavy rainfall. The northeastern portion, however, is subject to intermittent droughts. The highest temperatures are recorded not in the Amazon Basin but in the coastal area further south; and in the far southern panhandle of the country, frosts and an occasional snowfall are encountered at higher elevations.

Southward lies a prosperous and densely populated region that is the economic heartland of Brazil and contains its largest cities. Sao Paulo, the largest city, is the principal industrial centre. Second largest is Rio de Janeiro, once the national capital and still the principal financial and commercial centre. Third is Belo Horizonte, capital of mineral-rich Minas Gerais. In the mid-1970s, some experts foresaw the triangle delineated by these three urban centres eventually growing into a single megalopolis.

In the extreme south, a small region wedged between the Atlantic Ocean and portions of the Argentine and Paraguayan borders is a stable and prosperous land of livestock raising, coffee culture, and coal mining. In the Amazon also is one of the most valuable of all resources - land. Brazil needs the Amazon area to make room for its burgeoning population, now at 144 million and expected to reach 220 million by the year 2000.

Brazil is the sixth most populous country in the world. With an average annual growth rate of 2.0 percent in the period between 1985 to 1989, it is now adding more than 2.9 million people a year to its population. This represents more than a third of the Latin American contribution to world population growth, Alves _et al_(1988).

Rapid as the growth of Brazil's total population has been during recent decades, its urban population has been increasing much faster in the 1980s - urban areas grew almost 80 percent faster than the total population. In the 1960s, they grew more than 70 percent faster. The gap between the two rates of growth is almost certain to persist, but in a converging pattern, throughout the rest of the century. The urban share in total population was 32 percent in 1960, 56 percent in 1970, 73 percent in 1988 and is projected to be around 80 percent by the year 2000, which is comparable to the urban share of most industrial countries today, Alves _et al_(1988).

The traditional Brazilian position has been generally favourable to a rapidly increasing population. Laws and regulations have imposed special taxes on unmarried adults and childless couples, and there have been various maternity bonuses encouraging large families. Population policy has been closely related to considerations of national security. From the beginning of its independent history, the country's leaders looked with concern at the sparsely populated frontier areas, and encouragement of settlement in those lands has been a continuing policy. This has resulted in the fact that Brazil attracted many emigrants including those from Arab countries whose descendants today constitute more than six million people. Brazil's rapidly growing population of 144 million is the world's eighth largest, with an enormous potential for development.

The Brazilian total trade surplus set an all time record in 1988 with US$ 19.1 billion as is shown at Appendix 1 (Table A1.03). The large increase in exports is due to record sales of steel products (US$ 4 billion), followed by transport materials (US$ 3.8 billion), and soybean products (US$ 3 billion). On the other hand, the total volume of imports has declined, reflecting poor economic conditions, including the drop in industrial output. The European Economic Community (EEC) surpassed the USA as the major importer of Brazilian products in 1988.

Farming has become a major driving force in Brazil's economy. Farm output has increased sharply, and so have sales of farm equipment. Agriculture and agro-industrial products now account for more than half of Brazil's exports and are a key factor in the growth in the gross national product projected for 1989.

Farmers have become vital to the government's effort to earn foreign exchange from increased exports. Brazil's agricultural exports in 1988 reached a record US$ 13.3 billion out of an estimated US$ 33.8 billion in total exports, making Brazil second only to the U.S. in farm exports. Still the world's top exporter of coffee and sugar, Brazil has risen to number 2 in soybeans and in 1984 headed the world orange juice market.

2.2 Development Projects

The Amazon river basin borders eight nations and is larger than continental USA. The river's 100 major tributaries hold a quarter of the world's fresh water; fully exploited, they could produce vast amounts of hydro-electric power. The tropical jungles have enough high-grade iron to meet world demand for four centuries, and immense reserves of bauxite, nickel, copper, tin, gold and timber sit untapped in the almost impenetrable forests.

To harvest these riches, Brazil is relying on a handful of massive projects. The most ambitious is the "Carajas" mining and industrial complex in Para State. It is being implemented following the "Carajas" Program which involves a US$ 62 billion scheme, projected to occupy a large area of eastern "Amazonia" (as large as the size of Britain and France combined). It has been criticized by Treece(1989)[(1)] and The Sunday Times(1989) due to the impacts on 13,000 Brazilian indians and on the whole rain forest ecosystem in the area and beyond. Also due to the fact that many governments, financial institutions such as the World Bank and state and private companies are participating in the "Carajas" Program. They are from EEC, Japan, USA and Brazil. Nevertheless, in the next few years different companies will be processing and shipping millions of tons of iron ore and other minerals to the port of Sao Luis for export to the USA, Europe and Asia.

[(1)]Critics such as:

" 'Carajas' Program is turning the region into a massive agro-industrial park of mines, smelters, dams, railroads, charcoal burners, ranches and plantations, and is transforming its people into a destitute, landless labour pool. While Brazil's enormous foreign debt is certainly a driving force behind the shift of capital into the region it is clearly also highly profitable for the companies directly involved. ... The Brazilian state company (CVRD) signed a series of contracts guaranteeing the provision of an annual 13.6 million tons of iron to European steel firms, reportedly at 'bananas' prices, Treece(1989, pg 30)."

One of the economic results of such a Program for the foreign investors has been reported by a European Commission member as:

> " these contracts contain favourable pricing conditions which will contribute to preserving the competitiveness of the European steel industry, Treece(1989) (pg 30)."

Many of Brazil's boldest development projects have, to some degree, been marred by the same sort of blunders and unforeseen events doomed earlier ventures. American shipping magnate Daniel Ludwig's vast enterprise on the Jari River is one such example - and the Brazilians who bought out his sprawling timber and rice plantations in 1982 have just begun to turn the project around.

Ludwig began his enterprise in 1967, when he planted some 259,000 acres of forest area with fast-growing trees that could be pulverized and turned into paper at a giant mill that had been floated up the river on barges. He built 3,000 miles of roads, planted thousands of rice paddies and constructed towns, one of them big enough to accommodate 6,000 people. But the costs of running the remote operations were enormously high. A consortium of Brazilian investors has worked long and hard to make Jari a going concern, and the project is now just beginning to cover its operational costs. But that success has been almost two decades in the making, and it will be many years before Brazil recoups the hundred of millions of dollars invested in the project.

The government, in Brasilia, hopes these massive undertakings will stimulate other commercial ventures, both around "Carajas" and along the 550-mile railroad leading to the Atlantic. The "Carajas" complex is the show-case of Brazil's efforts to boost its exports - in part to generate the money needed to service its US$ 120 billion foreign debt, the largest in the developing world.

Other major projects are also coming on line. In the east Amazon, near the city of Belem, a series of aluminium processing plants began operations in mid-1985. The first electricity flowed from the huge Tucurui Dam on the Tocantins River in 1986. The dam will be able to produce 8,000 megawatts at full capacity, enough electricity to meet the meeds of the "Carajas" and Belem aluminium projects and to power a city of 4 million people. It is the fourth largest dam in the world and the first of a score of immense water and hydro-electric projects that Brazil hopes will contribute towards part of the manufacturing and agricultural development to the Amazon.

Brazil's massive mining and timber operations are prey to the whims of the often volatile global commodities markets. Vast "single crop" plantations are highly susceptible to pests and diseases. Consequently, "Carajas" is replanting cleared areas with a variety of different species.

That possibility underscores the Amazon's ecological fragility. Time and again, enterprises there have floundered on ignorance, and a fundamental lack of awareness of the intricate web of interdependences among the region's myriad species of plants and animals. Lumber plantations have failed due to their owners lack of knowledge about the Amazon's climate, soil and insects. Farms have been wiped out after a few years of high productivity because much of the Amazon's soil lacks many basic nutrients and, when cleared, is unusually vulnerable to erosion and leaching.

Brazil's ambitious attempt to conquer the Amazon, a territory of immense riches and potential, is still a giant national gamble that could go awry. Wrecks of previous grand schemes are strewn throughout the Amazon's history. Henry Ford and Daniel Ludwig, two of the world's richest men, both lost massive amounts of money when they tried to make money by exploiting the Amazon's rubber and timber. In the past, the Brazilian Government has done better, but its economic successes have also created serious problems. The gargantuan construction and colonization projects have taken a severe toll on the fragile Amazon ecology and on the indigenous inhabitants, and the region's extractive industries are usually vulnerable to the whims of the global market. Nonetheless, Brazil is pushing ahead with its development plans.

Scientists now agree that the Amazon produces most of its own rainfall and they suggest that widespread cutting could turn large swathes of the rain forest into near desert. A few researchers even claim that large-scale clearing could enhance a "greenhouse effect", in which the destruction of forests and burning of fossil fuels would increase carbon dioxide levels in the atmosphere raising global temperatures and possibly causing the polar ice caps to melt. Such scenarios may be unduly alarmist, but they make an important point. If the Amazon is not developed judiciously, the forest's riches could vanish once again.

Brazil hopes to satisfy part of the ever growing needs of its population and export markets, producing food and technology appropriate to the conditions of developing countries. For this purpose, there still exist, in addition to the Amazon region, vast areas of territory with high aluminium content and low pH soils to be reclaimed. The overall climatic conditions for these areas are favourable: good average yearly temperature, well-distributed rainfall and sunlight during most parts of the year.

The role of fertilizers is, needless to say, of the utmost importance for the "Cerrado" areas (1,800,000 km^2), which require phosphate as the principal element for agricultural purposes. Nevertheless, to face the challenge from phosphate producing countries, which, in a similar way to OPEC's affiliated countries increased prices by almost 400 percent during 1973/74, Brazil has set out to activate new domestic sources of phosphate rock, whose processing has become feasible, in spite of low contents as compared to the Florida and Morroco ores. Also, intensive work on mineral research has been done.

As a result of these efforts, the sole phosphate production of the Serrana Group at Jacupiranga, Sao Paulo State, was followed by mining activities at the deposits in Tapira and Araxa (Minas Gerais State), Catalao-Ouvidor (Goias State) and finally Patos de Minas, again in Minas Gerais State.

2.3 Agricultural Development

The low agricultural production growth rate in Brazil after World War II was the result of a combination of factors, which included: lack of agricultural research institutions and research tradition; limited extension services; lack of an infrastructure to serve agriculture; and price and tax policies designed to lean most heavily on agriculture, thus acting as a disincentive to agricultural production. In addition, import substitution industrialization was adopted as a growth and development strategy by the government, resulting in a continuous transfer of resources from agricultural to the industrial and service sectors. This neglect of agriculture also caused domestic supply problems until it gradually became clear that unless production was adequate to supply the growing domestic[2] demand for food, general stagnation would occur.

Brazil did not participate in the growing trade in agricultural products which characterized the post-World War Two period, until the mid-1970s. As a result, the demand for agricultural products for export was kept relatively low. This problem was further complicated by the fact that export quotas were placed on agricultural products from time to time under the guise of controlling domestic inflation. This further dampened demand for agricultural products and reduced the incentives for output expansion.

In the mid-1960's, economic policy underwent a change of emphasis from industrial import substitution to aggressive export expansion in which agricultural and agro-industrial products played a major role. Overall performance of the Brazilian economy also improved, resulting in an 11 percent growth rate in Gross National Product (GNP) in the 1966-73 period.

As a result of this policy change, Brazil became an often quoted example of a country which had managed to achieve significant agricultural development in the decade of the 1970s. In the early 1980s, it also became the second largest exporter of agricultural products, surpassed only by the USA. Brazil is thus rapidly becoming an agricultural world power.

In the past decade, Brazil's total agricultural production has tripled, and not all of the growth has come from crops traditionally associated with tropical

[2]The demand quantity of agricultural products in Brazil has presented a growth rate of about 5 percent per year, Alves et al(1988).

farming. For example, when the USA curbed soybean exports to Japan, it turned to Brazil to supply this crop. Soybean output in Brazil increased from 2.2 millions tonnes in 1974 to somewhere in excess of 20 million tonnes in 1988, overtaking coffee as the country's number one export crop.

The principal factor responsible for the growth of agricultural output in Brazil, until the mid-1970's, was the expansion of the cultivated area, in addition to some productivity increases, mainly with export crops, in older areas. The scientific frontier in terms of increased productivity of land, labour and modern inputs, was little explored.

Brazilian agricultural policy initially emphasized building extension institutions. However, at an early stage it became obvious that for successful operation of extension services, a strong research system had to be developed to provide new knowledge and technology to be used in giving technical assistance to farmers. As a result, EMBRAPA, the Brazilian Agricultural Research Corporation, which has become one of the strongest agricultural research systems in the developing world, was created in 1973 and developed in the period 1973-1984.

The Sarney administration in addition to continuous support and integration of research and extension, has made a moral commitment to implement land reforms limited to non-cultivated agricultural land and thus eliminate agricultural land as a speculative commodity and means of capital gain in an economy with a high inflation rate.

Land ownership structure, a result of economic conditions and the course of history, may be blamed, to a certain extent, for the unjust distribution of income within the region. However, personal income could hardly be increased in a significant way if a comparatively small area of fertile land were to be distributed among the growing population. Under these conditions, and although present Government efforts to re-distribute some poorly used or abandoned land are fully justified, a major effort must be made to improve the land resource, mainly through a major increase in irrigated areas to decrease fluctuations in the staple food supplies. This may represent a viable alternative to past attempts to resettle Northeastern farmers in the Amazon region, where land is plentiful and even the worst soils seem to be better than those of semi-arid regions.

2.4 The Rural Credit System

At present there is much criticism of the agricultural credit system which has constituted the major vehicle of agricultural development over the last two decades. The following appraisal is based on a world Bank Study entitled Brazil Financial System Review, (World Bank, 1984) and on Anderson(1986).

2.4.1 Rural credit administration

Brazil's complex financial system over the past two decades has played a central role in the evolution of its economy in general, and agriculture in particular. Financial arbitrage and the search for favourable credit terms absorbed scarce entrepreneurial and managerial resources in the agricultural sector with a high opportunity cost in terms of output. Different financial assets were linked to specified types of loans, creating separate financial sub-systems within agricultural production systems.

Powerful financial feedbacks amplified the effect of exogenous disturbances and accelerated inflation, which then became institutionalized in Brazil's highly indexed economy and affected in different ways the production of various crops and animal products.

Brazilian economic policymakers have a long history of simultaneously taxing and subsidizing agriculture. Subsidized agricultural credit initially was justified as providing partial compensation for the anti-agriculture biases associated with Import Substituting Industrialization policies which were pursued after 1930.

Low rates of interest for agriculture have long been a feature of Brazilian policy although the volume of rural credit did not become significant until the 1960s. Agricultural marketing policies and controls are among the main factors, together with credit, making up the economic environment of the Brazilian farmer. These policies make use of price supports, retail price controls, subsidies, tax credits, quotas, licenses, and taxes.

As a consequence of economic policies Brazilian agriculture shifted from increased production of domestic food crops before 1960s to increasing production of export crops in the 1970s.

The significant growth of subsidized rural credit in size and expense began after the creation of the National System of Rural Credit (NSRC) in 1965 with objectives such as: the stimulation of rural investment, the encouragement of the production and the adoption of advanced technologies, the improvement of the marketing services of agricultural outputs and some adjustments of the rural income distribution.

The members of the NSRC include the Central Bank, the Bank of Brazil and the other commercial banks. Their inspectors are bank functionaries with no experience in agriculture, who cannot easily discern the appropriateness of different technological packages.

Although the total number of lines of credit has been estimated at no fewer than 170, rural credit is generally provided in three broad ways:

(a) short-term operating credit, and credit for certain subsidized inputs;

(b) medium - and long-term investment credit, for up to 12 years; and

(c) short-term marketing credit. In 1978, when inflation was 41 percent per year, nominal interest rates for subsidized inputs ranged from 0.7 percent and for other purposes 13-21 percent per year.

Details of negative real rates of interest derived by subtracting the rate of inflation from the official ceilings have been shown by Anderson(1986),(pg 12).

The most striking feature of Brazilian rural credits has been the amount of money involved: the volume of credit in 1976 was some US$ 15 to Us$ 16 billion, roughly equal to the net value of agricultural production. Almost equally striking, however, is the paucity of empirical evidence as to what has been achieved as a result. Much essential information is still lacking. It is known how loans were made, but not how many farmers received them, nor the comparative output, productivity or profitability of those using more or less credit, or no credit at all. The value of the available information is, moreover, vitiated by the fact that perhaps 20 to 30 percent of the total rural credit is estimated to have been diverted to other uses, (World Bank, 1984).

From 1969-76, while the share of agriculture in Gross Domestic Product (GDP) remained fairly constant and the net value of agricultural production roughly doubled, the total annual volume of rural credit increased four and a half times. In addition, the increase in credit (to perhaps 20 to 25 percent of farmers) was over 138 percent of the increase in the Net Value of Product (NVP) of all farmers; in 1975 and 1976, the value of credit was roughly equal to NVP. The implicit subsidies in 1978 were to the order of 30 percent of total NVP.

The distribution and use of credit during the period 1969-76 showed the following trends. Investment credit increased more rapidly than that used for other purposes. In the case of operational credit for crops, the most dramatic increase in real terms was shown by soybeans (over 20 times) followed by wheat (over seven times); on the other hand, the increase in credit for soybeans was only 46 percent of the increase in the gross value of production, while for wheat it was 136 percent. The use of operational credit for export crops and wheat was strikingly higher than that for traditional staple foods. Credit use, during this period, was more intensive in the developed regions of the South and Southeast than in the North and Northeast, with the number of farmers taking credit varying from about one in three in Sao Paulo to perhaps one in 30 in the Northeast. Credit to large farmers increased much more rapidly than that to small farmers, though in Sao Paulo less than half of larger farmers used formal credit in 1977. Some institutions representing different segments of the society started to criticise the allocation of agricultural credit but such disequilibrium continued until the end of 1980's when occur a significant reduction in the amount of agricultural credit available for the Brazilian agriculture as a whole.

Although very little is known about the cost of administering the rural credit system, its complexity and the attempts to regulate the use of subsidized funds suggest that such costs are very high. This would seem to be borne out by the level of the Bank of Brazil's administrative costs which were some US$ 1.5 billion in 1978. In addition, there are the costs (about 1 percent of the amounts financed) of agricultural consultants, since technical and financial plans and projections are generally required. These plans appear to take no account either of inflation or of the overall financial position of the farm and its results in previous years. The credit regulations, which were numerous and complex, created a heavy burden of administrative work which has occupied much entrepreneurial, professional and bureaucratic time.

2.4.2 Users of subsidized rural credit

The effects of subsidized rural credit can be only broadly assessed because much important information is either lacking or of doubtful accuracy, the influence of the subsidies is inextricably mixed with that of other policies. By the same token, the subsidies are a very crude and haphazard instrument of policy.

Some effects of the credit subsidies, however, seem fairly clear. Since the value of credit, which was received by a minority of farmers in the mid-1970s, was about equal to the net value of the production of all farmers, much risk capital must have been diverted from agriculture. At the same time substantial transfers of real income were made to larger farmers. In addition, since land is a means of obtaining subsidized credit, increased land prices and concentration of ownership have been encouraged. Moreover, the increases in production, if any, from the subsidization (as distinct from the availability) of credit, have been obtained at very high cost. Apart from the diversion and substitution effects noted above, credit takers have had their total, not just marginal, production subsidized. The survival of inefficient farms has been encouraged, along with the wasteful use of resources, Yeaganiantz(1988, pers. com.).

The view that credit subsidies are justified because they compensate agriculture against protectionist policies is unconvincing, because the subsidies would have a positive economic effect only if they were evenly distributed across the sector altogether. In fact, they were highly concentrated and, to a substantial degree, diverted from the sector. Finally, subsidized credit tended by nature, to be undesirably discriminatory. Farmers not receiving subsidized credit share not only in the policy-imposed disadvantages of agriculture but also in the cost of the measures that are supposed to offset them.

In spite of various reforms small farmers with relatively efficient operations have difficulty in obtaining credit, either because they live in remote areas, or because the volume of business they bring is too small relative to the administrative costs of serving them, Anderson(1986). The experience of many countries suggests that traditionally the provision of credit to large numbers of small farmers individually through the banking system is very costly and probably uneconomic. In such cases, the costs in real terms are normally at least to the order of 20 percent of the amount lent. In many countries, for this reason, attempts to lend to small farmers have generally been made through Government-owned banks. Unfortunately, these Institutions with typically high costs, have required constant subsidies, have often had low recovery rates, and have been in some cases subject to political intervention, (World Bank, 1984).

Larger farmers in more developed regions tend to use more credit because of the technology and scale of their operations and because of their greater credit worthiness. Although attempts are made with some success to direct rural credit to small farmers, credit use within this group appears to be highly concentrated and perhaps over-intensive on some of the farms. Again, tenants are less likely to have access to benefits of subsidized credit, both because of their status and because they predominantly operate smaller farms. In addition, the more developed areas receive further substantial benefits from wheat subsidies.

While the price of land has increased out of proportion to what can be earned from it, the protection of local industry (by high import tax rates) affects the price, quality and range of inputs available to the farmers. Moreover, they suffer the full effects of inflation. Inflation, which is itself fuelled by subsidized lending, increases the working capital requirements of agriculture more than that of most other sectors, because of the seasonal nature of production. So, farmers without subsidized credit are either obliged to do without inputs they would otherwise buy, or to borrow from other sources where interest rates have been forced up by attempts to apply restrictive monetary policies. Moreover, they are placed at a competitive disadvantage to the extent that credit does succeed in increasing productivity.

2.4.3 Rural credit policies

The following suggestions mentioned in the World Bank report (World Bank,1984), indicate the broad direction in which rural credit policy has already moved or should move and some of the objectives which it should seek to achieve.

Subsidized agricultural credit is frequently justified as necessary to offset protectionist policies favouring industry and agricultural price controls and marketing restrictions. Where, for some reason, protection of a domestic industry producing agricultural inputs (fertilizers) is desired but agriculture is not to be saddled with the cost, the best policy is producer subsidization. While this is equivalent to protection plus consumer subsidies, the subsidies could be paid at production source rather than through subsidized credit to farmers for the purchase of inputs. The advantages of this would be that the cost of protection would be more transparent, administration would be simpler because input producers are fewer than farmers, and, there is less likelihood of promoting overuse or misuse of the product, or diversion of the subsidy.

After 1982, interest rates have been progressively increased for operating, investment and marketing loans, and selective special credit programmes phased out. Credit reforms have narrowed interest rate differentials and have reduced capital market fragmentation. During the transition, subsidized rates have been linked to market rates through specified discounts financed through the fiscal budgets. Beside offering macroeconomic advantages, they have permitted the charging of different interest rates to different clients and types of enterprises, and so they have reduced the tendency for subsidized credit that has forced lenders to concentrate on low-risk, established clients.

Elimination of credit subsidies should have been accompanied by other reforms to increase farm profitability. Marketing constraints now inhibit the responses of producers in terms of output because they depress prices and raise uncertainty. Farmers need unobstructed access to markets and the assurance that the government will not intervene to change the "rules of the game" unexpectedly.

Brazil now faces a difficult adjustment period. The role of the financial system in this adjustment should be to mobilize more domestic resources through voluntary savings and to allocate them more efficiently. To achieve these objectives confidence must be restored and this in turn, will require stable financial policies within a medium-term adjustment framework.

Anderson(1986) has discussed other important aspects concerning Brazilian agricultural credit. These include advance limits and loan sizes, guarantees, credit insurance, and minimum prices. Also, she has mentioned some movement toward a diversification of agricultural policies which was made in 1970s with the creation of the EMBRAPA and the Brazilian Rural Extension Enterprise (EMBRATER) and with the initiation of some infrastructure investment projects.

Among the criticisms on subsidized rural credit policy, which are presented by Anderson(1986), is the following:

> " the harmful side effects of subsidized Rural Credit programmes are the discouragement of rural savings, brought about by low interest rates and institutional deterioration; and the diversion of development resources from potentially more beneficial policies like agricultural research." (pg 35).

2.5 Recent Orientation

During the past thirty years, Brazilian economic growth has been rapid, bringing material well-being to a considerable portion of the population, Yeaganiantz (1988 pers. com.). Today the wealth, evident in all large Brazilian cities, is impressive, but enormous social problems do persist.

Since 1985, the New Brazilian government has given investment in basic public services a greater emphasis. For example, investment in water supply and sewerage under the national sanitation plan has been accelerated, an urban sites-and-services programme and a construction materials loan programme have been launched to make possible the self-help construction of low-cost housing, and a new programme has been established to provide basic health care in rural areas. Other programmes, such as the integrated rural development projects in the Northeast, including elements of health education, sanitation, and water supply as well as agricultural credit and extension, and the national nutrition programme, are also designed to help meet the basic needs of the poor while increasing their productivity.

Alternative development strategies for the future, once discussed only by small groups of intellectuals, are now widely debated in the press and within the government, the universities, trade associations, unions, and political groups. This new climate has encouraged attempts inside and outside the government to evaluate what has been achieved so far in the development process and what remains to be accomplished.

It is by no means certain that society will adjust readily and smoothly to changes in the relative availability of natural resources such as ground water for irrigation. Numerous examples may be cited in which a society's perceptions of and responses to changing conditions were inadequate to avoid a deterioration in living conditions. The energy crisis is a recent example. Similarly, the full costs of industrialization and urbanization were not obvious until air pollution and congestion made some cities virtually uninhabitable for many people. Free market forces have not proved a reliable guide for an efficient exploitation of ground water stocks. The market underprices the full cost of present ground water use, encouraging a faster than efficient use of stocks. In some cases, overuse has required costly "rescue" investments to avoid large income and investment losses.

2.6 Current Situation

More recently Brazil's economic situation has worsened with many major economic plans (involving wage and price controls) such as "Cruzado Plan" in 1986, "Bresser Plan" in 1987 and "Summer Plan" in 1988. Despite this dismal economic picture[3], exports were at record levels in 1988, agricultural production was good, and the "informal" economy has increased.

Although the Brazilian congress promulgated Brazil's new constitution in October 1988, the current outlook for the next few years involves many political and economic uncertainties, Wicks(1989). Appendix 1 presents some statistics of the Brazilian economic situation with an emphasis on the agricultural sector.

The foreign debt, agrarian reform and environmental issues related to the Amazon region are key problems for the presidential election in November 1989.

Despite the tendency of Brazilian farmers to view the availability and cost of credit for agricultural

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[3]Brazilian economic performance during 1988 was characterised by stagflation with all time record inflation rate of 933 percent, and a zero economic growth, Wick(1989).

production as the key factors in formulating planting intentions, the government's production price and credit system continues to be reformulated in order to reduce the credit subsidy cost and inflationary impact of the programmes, Wicks(1989). This short term policy has been adopted due to economic difficulties.

Fertilizer and pesticide consumption are calculated on the basis of domestic production plus imports, Appendix 1 (Tables A09 and A10).

From a volume of credit around US$ 15 to US 16 billion in 1976, the NSRC budget dropped to less than US$ 1.5 billion (in real terms) in 1989. Furthermore, the interest rates have changed drastically. Of the amount approved for the 1988/89 crop at NCz$ 1.369 billion (Cruzados Novos) (or US$ 1.369 billion as of 16 January 1989), only approximately US$ 569 million has been available at favourable interest rates of 7 to 9 percent plus inflation, and US$ 800 million at free market rates. The reason for this reduction was the strong internal and external pressure to reduce federal deficits associated with the short term viewpoint of the Sarney administration policymakers.

In order to guarantee production of basic food staples the government has maintained "attractive" credit financing levels for corn, sorghum and manioc (cassava) crops.

Some steps toward trade liberalization are being implemented through a price stabilization system.

Brazil's first Farm Bill is being discussed by the Brazilian Congress. Several farm groups are preparing alternative drafts of this Bill, which promises to be one of the most important issues to be dealt with by Congress in 1989. The following issues dominate the debate over these first agricultural laws: agrarian reform, government intervention in the sector, taxation, farm income stabilization, production policies, agricultural trade, and stocks. Wicks(1989) has observed that the drafts of the new and first Brazilian farm bill reflect

> " the strongly nationalistic point of view of Brazilian farmers, exuding the protectionist feelings that dominate the sector. Competition from other countries is not welcome and will likely be avoided in large part with the passage of the Bill." (pg 21).

It is certain however that over the next few years Brazilian farmers will not be able to rely on high levels of government subsidies such as farmers from USA have enjoyed (over 30 percent of net farm income in 1987), Lanpher(1988).

2.7. Agricultural Problems in the "Cerrado"

Brazilian resource surveys are incomplete . However, it is apparent that in Brazil there is a diversity and wealth of resources available for exploitation and development.

With an area of 8.5 million km^2 Brazil has less than one tenth of its area being more than 800 m above sea level. The highest areas are in the south-east and the far north. Lowland's areas below 200 m constitute 40 per cent of the Brazilian territory and are found mainly in the Amazon Basin, the "Pantanal" and along the Northeast coast.

The upland plateaux, or "planalto" areas between 200 and 800 m altitude are the most extensive Brazilian relief forms. Small areas with higher plateaux occur in the south-east and south (Map 2.1), which include areas of up to 1200 m.

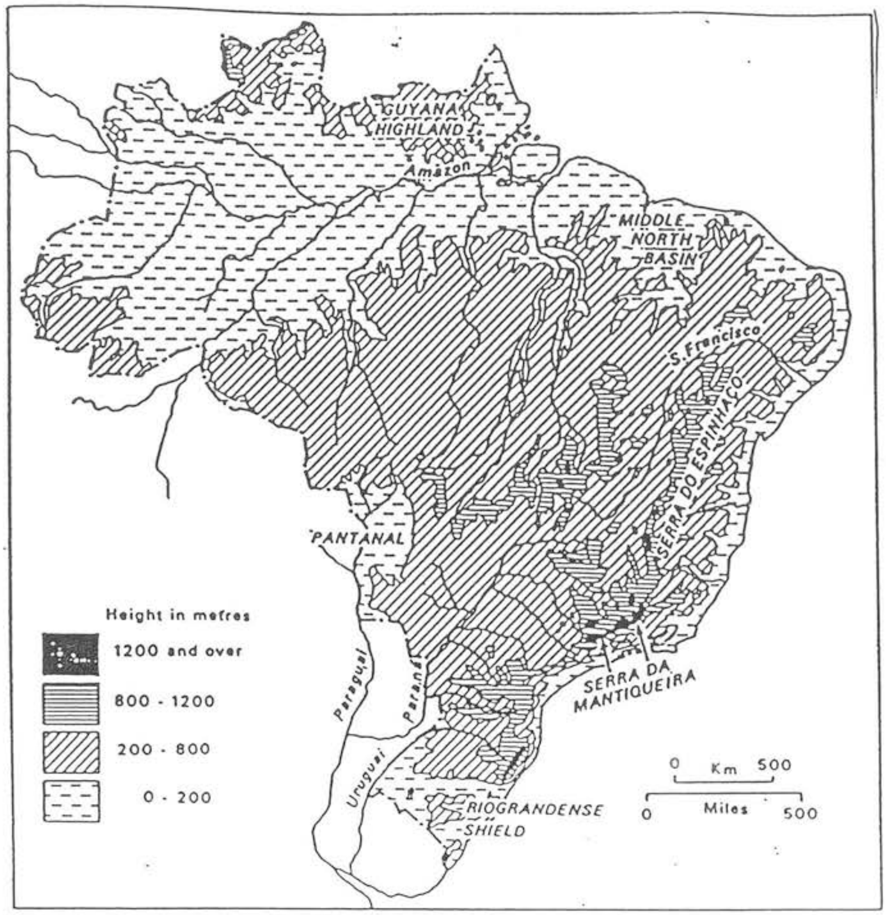
In the tropical savanna areas that are identified in Map 2.2, a dry season marks the transition to the more seasonal rainfall pattern. The large savanna region in the Planalto Central and Middle North has a pattern of summer rain and winter drought, with over 80 per cent of the rain falling between October and March. The amount of rainfall in this region is between 700 and 2,000 mm.

In addition to the distinct seasonality of rainfall, the area's vegetation is mixed in character, with strata of dispersed, low contorted shrubs and herbage. Three or more sub-types, depending upon variations in shrub density, are recognized, and within these general groups a considerable amount of diversity exists.

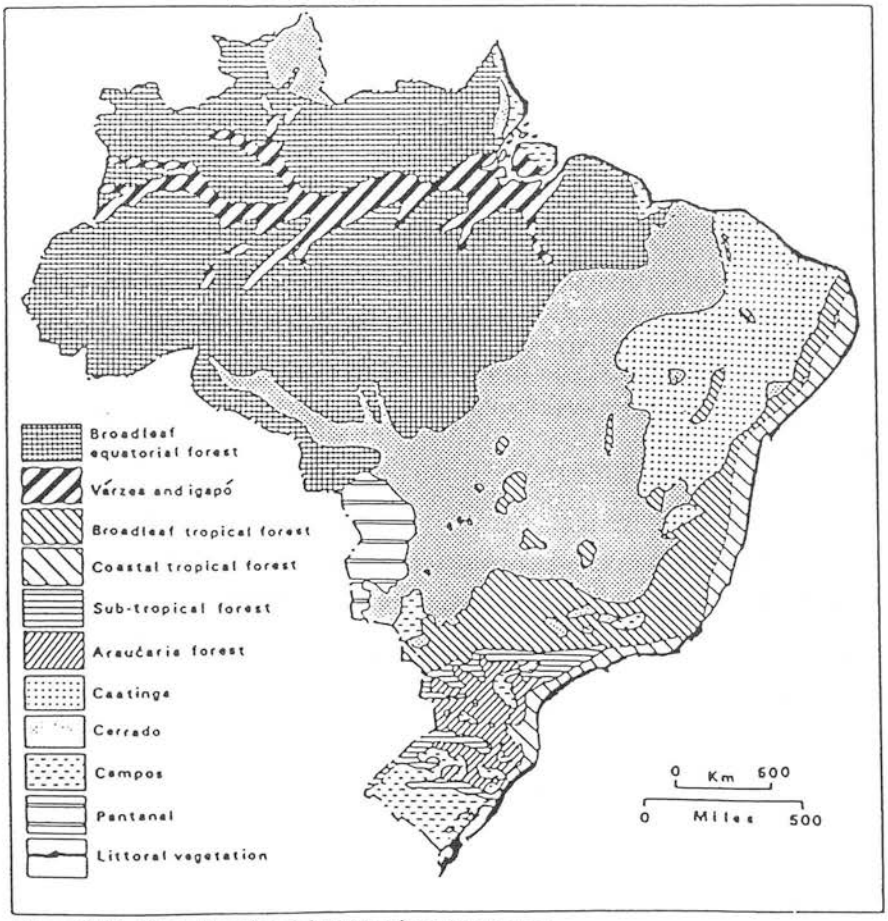
In this large savanna region, known as "Cerrado", there has, until recently, been little agricultural development.

Its total area is about 200 million hectares or 23 percent of the Brazilian territory and it is estimated that at least 50 percent of the area could be used for crop production. It has been estimated by Adomoli(1986) that 73 percent of the "Cerrado" areas lie at altitudes between 300 and 900 m.

The population of the "Cerrado" region in 1988 has been estimated at about 15 million people which represents about 10 percent of the Brazilian population. However, in the "Cerrado" region the available infrastructure in terms of transport, marketing, storage, agro-industry and basic input industries (such as fertilizers and lime) offers better conditions for agricultural production expansion that other Brazilian regions.



Map 2.1 Brazil: Relief and Drainage.
Source: Dickenson(1982) Brazil.



Map 2.2 Brazil: The Vegetation Pattern.
Source: Dickenson(1982) Brazil.

The "Cerrado" soils are acid and have a high aluminium content. They are commonly very deficient in phosphate, but they have high phosphate absorption capacities. Consequently, large additions of lime and phosphate fertilizer are required to reach their crop yield potential. These and other technological problems related to "Cerrado" soils have been outlined by Kornelius(1981) and Goedert(1983,1988) to explain in technological terms why no more than 23 percent of the "Cerrado" has been cultivated (7 percent with grain, cereal and vegetables crops, 1 percent with tree crops and 15 percent with improved grassland).

One of the reasons for the low percentage of cultivated "Cerrado" is that little of the extensive area used for pasture is improved grassland, so that the non-cropped areas include substantial tracts of natural vegetation natural grassland, shrub, cleared woodland or native forest. It is also estimated by Goedert(1988) that in relative terms, its area of natural grassland is 39 percent and its area of native forest is 38 percent. Consequently, an irregular pattern of cropland, intermixed with extensive pasture and unused land, forms the farming landscape of the "Cerrado" region.
This suggests that much of "Cerrado" agriculture remains traditional, with larger units that are farmed less intensively. Land is cleared by slash and burn techniques. The soils are put under a limited rotation of crops; consequently, yields decline, and plots are abandoned and new ones opened up. Commercial agriculture with modern inputs of improved seed, better stock, fertilizers and so on is limited and has occurred only in specific places where the government has provided subsidized capital.

The persistence of traditional patterns and practices is evidenced by the limited improvement in productivity. Traditional crops such as maize and rice have shown increases in production, but the cultivated areas under these crops has risen also. For rice, the average yield per hectare has tended to fall, not increase.

However, Goedert(1988) has outlined that during last decades the Brazilian "Cerrado" agricultural frontier has expanded significantly due to factors such as: the increase in demand for agricultural products, the creation of the Brazilian Federal District with Brasilia City at the "Planalto Central Brasileiro", its location in relation to the main consumption markets, and the agricultural potential of large areas of its soils.

Kornelius(1981) has described that large part (52 percent) of the "Cerrado" soils are Latosols (Oxisoils) with yellow red and dark red types and low natural fertility (high aluminium saturation, low pH and very low phosphorus levels). However, the good physical characteristics (deep and quite permeable) and a favourable topography makes them appropriate for year-round mechanized agriculture. The other "Cerrado" soils are:

. The Ground Water Laterites (Utisoils) which occupy about 11 percent of the "Cerrado" region. They present low natural fertility and very poor drainage during the rainy season.

. Quartz Sands or Entisoils which present very low natural fertility and occupy some 20 percent of the "Cerrado" region.

. Lithosoils or Afisoils which present in general, low fertility and serious physical limitations. They occupy about 13 percent of the "Cerrado" region.

. The fertile purple Latosols (Haplustox) which occupy about 4 percent of the "Cerrado" region.

The introduction and substantial expansion of soybean production has brought important changes to the cultivation of the "Cerrado". It has changed the concept of the value of the land and its use. However, the production processes which have been developed by farmers can be technically improved upon by for example better soil management and fertility correction methods. Such improvements need first to be made viable in economic terms before they will be carried out.

After describing some experimental results which show the potential of the "Cerrado" soils, Goedert(1983) emphasized the following:

> "... the solution to soil-related constraint for tropical soils does not depend solely on the efforts of soil scientists, but on the contribution of several other disciplines. Only a multi -disciplinary approach will lead to the development of rational and sustained farming systems for the tropical region...".

At a higher level, the Brazilian Government has established as a research priority, the development of technologies and viable production systems, in social and economic terms, for the establishment of specific projects (EMBRAPA/MA, 1985). This involves a resource management problem where capital and alternative technological packages are fundamental aspects.

Due to the fact that capital is a limiting resource, rural credit policies involving low interest rates and other factors must be studied in social, economic and managerial terms.

Analysing agricultural development projects in the "Cerrado" region, important policy questions were raised by Tollini(1987, pers. com.):

> "How much should society pay in order to make it possible (profitable) for farmers to transform the "Cerrado" region in a productive area. How should this subsidy be transferred: through interest rates, through fertilizer and lime subsidy, or through some other policy?"

This study tries to show the maximum that the producer can pay both in the long and short-terms and the minimum that society will have to subsidize the producer in order to incorporate new "Cerrado" areas into the production system under various input and output prices.

In Brazil, less destructive policies towards the Amazon region will emerge only if researchers, analysts and decision makers can demonstrate, in the next twenty years, with well elaborated development projects[4], that the "Cerrado" region is the better alternative area for frontier expansion . Among other measures for specific sub-areas, there will be a requirement for "strategic control over the impact of spontaneous, unplanned clearance of migrants, whose individual impact may be substantial", Dickenson(1982).

Thus, the economic and managerial factors involved in exploring the potential of the "Cerrado" region should be studied at the farm level as a possible contribution to the elaboration of development projects for the "Cerrado" region.

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[4]Such development projects must consider a multiple objective approach where the environmental, regional, social, financial and economic objectives would be assessed.

Chapter 3 Agricultural Aspects of the "Regiao Geoeconomica de Brasilia" (RGE)

3 Agricultural Aspects of the "Regiao Geoeconomica de Brasilia" (RGE)

3.1 Location, Area and Climate

The RGE is located in the "Cerrado" central area: the 235,592 km^2, are between the co-ordinates 45^0 and 50^0 longitude and 12^0 and 19^0 45' South latitude and represent 11.6 percent of the whole "Cerrado" Region and 2.8 percent of the Brazilian territory. It includes 89 towns and the Federal District of Brazil of 5,771 km^2.

Its climate is characterised by two distinct periods: a dry period with rare rainfalls (May to September) and a rainy period (October to April) with heavy rainfalls. The average total precipitation is up to 1600 mm and the annual average temperature gradually decreases from Northwest (25^0C) to Southeast (21^0C).

3.2 Natural Resources

The natural resources of RGE are characterised by "Cerrado" (savannas) with vegetation up to 15 metres high and is marked by large areas of acid and low fertility soils[(1)] at an altitude which varies from 300 metres to 1,500 metres. However, such soils have a good structure (deep with good drainage). The Table 3.1 described by Kornelius(1981, pg 23), shows an approximate distribution of major soils units in the continuous area of the "Cerrado" region.

The hydrographic resources are extensive with great irrigation potential in three different basins (Tocantins

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[(1)]"The level of aluminium saturation is high, while phosphorus levels are very low; these soils strongly fix phosphorus into unavailable forms", Kornelius(1981, pg 24).

River Basin, Sao Francisco River Basin and Parana River Basin). Map 3.1 shows the distribution of the main rivers and a national park in the RGE.

Table 3.1 Approximate Distribution of the most Soil Units of the Continuous Area of the "Cerrado" in Relation to the Soil Taxonomy and the Brazilian System.

Brasilia system	soil taxonomy order	great group	total area (millions of ha)	"Cerrado" (%)
Latossolos	Oxisols			
Latossolo Vermelho Amarelo		Acrustox	69.9	41
Latossolo Vermelho Escuro		Haplustox	17.9	11
Latossolo Roxo		Haplustox	06.9	04
Areias Quartzosas	Entisols	Quartzipsamments	34.3	20
Laterita Hidromorfa	Ultisols	Plinthaquults	17.0	10
Podzolico Vermelho_Amarelo Distrofico		Ustults	02.1	01
Podzolico Vermelho_Amarelo equiv. Eutrofico	Alfisols	Ustalfs	07.0	04
Litossolos		Lithic groups	15.1	09
Total			170.0	100

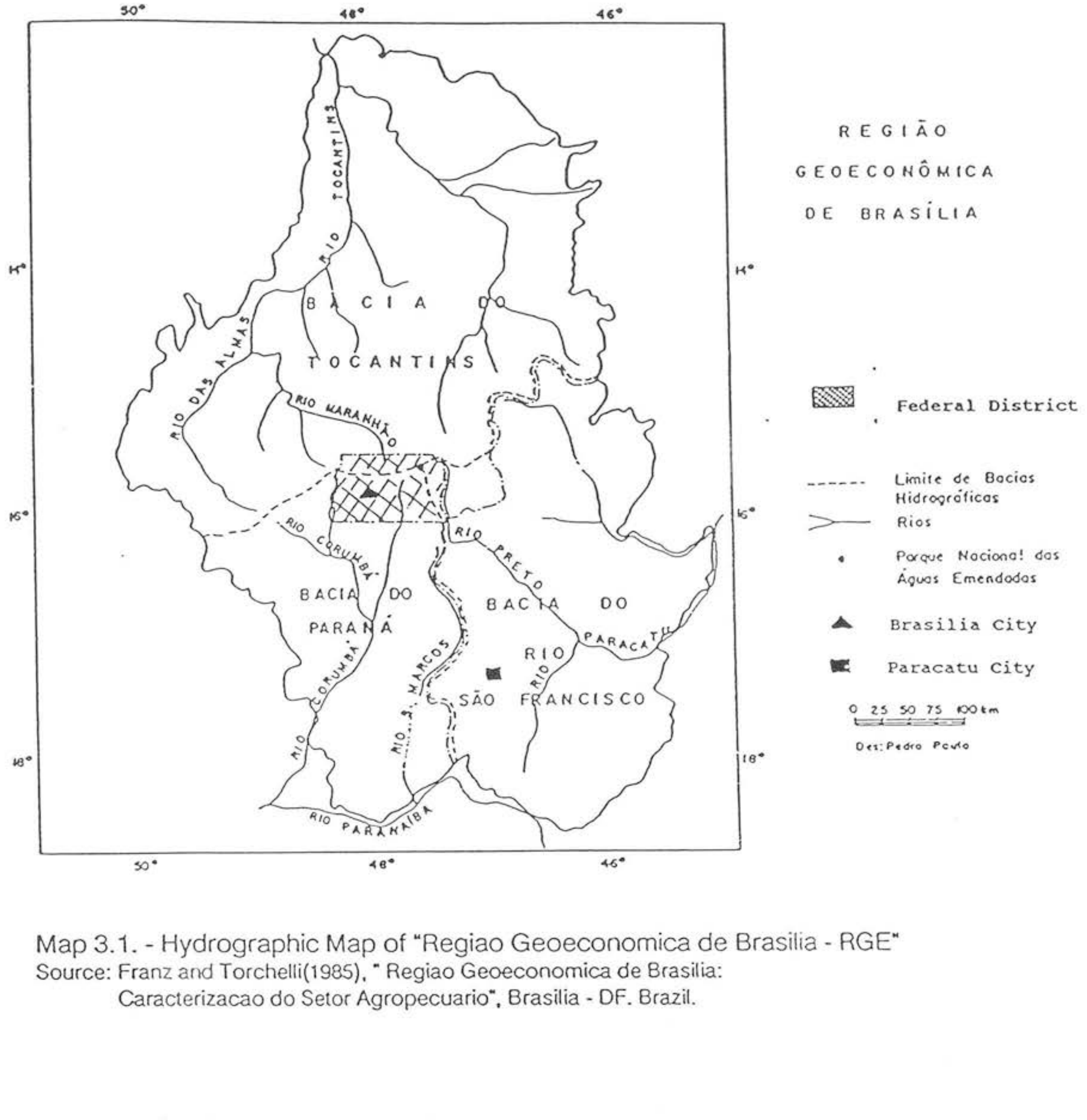
Source: Kornelius(1981) Optimal Farm Organization for the "Cerrado" Region of Brazil, PhD Thesis, Univ. of Florida, USA.

3.3 Population and Economic Structure

It was estimated in 1985, that there was a population of about 3,000,000 people in the RGE with more than 50 percent living in the Federal District, Franz et al(1985).

The regional market has shown significant development in the last decade due to the good infrastructure (such as: transport, energy, telecommunications) required to link the Brazilian Federal District with the most important Brazilian regions.

3.4 Rural Development



Map 3.1. - Hydrographic Map of "Regiao Geoeconomica de Brasilia - RGE"
Source: Franz and Torchelli(1985), " Regiao Geoeconomica de Brasilia: Caracterizacao do Setor Agropecuario", Brasilia - DF. Brazil.

In the last twenty years, different policies have been used in "Cerrado" agricultural development, and the RGE has received large amounts of the capital investment used for such purposes. For example, it has a reasonable infrastructure for agricultural research which has been fundamental for agricultural development in its low fertility soils. However, such policies have not covered all of the important aspects of integrated rural development.

Large areas of the RGE are still unexplored. For example, at the "Planicie" area in the Paracatu District, no more than 20 percent has been explored for commercial crops and cultivated pastures in beef cattle production systems, Carneiro(1986).

Given the low education level of a large part of the rural population, cooperative systems between farmers are not well developed. No more than 50 percent of the farmers have used rural credits and in general such credits have been applied to crop maintenance, Anderson(1986).

Some public institutions give support for agricultural development in RGE. State level institutions, for example, have worked in collaboration with some local institutions such as farmer cooperatives. But, their public services are, in general, not effective due to large bureaucracies staffed by low salaried workers.

The banking system has improved its services for farmers. However, the farm management services that have been provided by government are deficient due to low budgets and advisers unqualified in farm business, Anderson(1986).

Rural electrification has been implemented on some farms in specific districts. However, most of the farms in the RGE are still without any electrical power. The rural schools are run on low budgets and with untrained teachers. The health services are inadequate due to the large number of diseases which result from malnutrition and other problems such as low quality water and insects. The agricultural development programs for the RGE are part of broad programs without well defined policies. So, in general the farmers have low incomes when they are not involved in highly subsidised projects. Furthermore, in the RGE as in the whole of Brazil, the structural problems correlated with land tenure, labour generation, soil conservation and other ecological aspects (such as ecological reserve law) important rural development, have not been satisfactorily solved, Ferreira(1985) and Franz(1988 pers. com.).

Describing four different periods of the New Zealand water and soil usage, McGregor(1986) has outlined the following:

- ."the first period as a period of unrestricted development of land.
- . the second period occurred in the passing of a Soil Conservation and River Control Act in 1941 and the establishment of regional water boards... more local interest in the problems of water and soil management;
- . the third period occurred with the increasing competition for land and water resources and awareness by the public that development did not have to always occur to the detriment of environmental, recreational and social considerations;
- . the fourth period has been characterized by the necessity of a new planning approach which solves conflict over the allocation of the water and soil

resources including public participation and the variety of political considerations ...,(pg 1-2)."

A large part of the RGE, like many Brazilian regions is now entering a development phase similar to the second period of development described by McGregor(1986). The ecological reserve law [2] has been precariously applied when a farmer decides to use his land to develop new crops, pasture, or charcoal activities. The public participation on such issues becomes difficult due to the low level education and poor communications.

In 1984, the total area in the RGE comprised 7 percent of commercial crops[3], 17 percent of cultivated pasture and 76 percent in "Cerrado" natural conditions, used basically for extensive beef cattle farming systems. Most of the commercial crop area was under: maize, upland rice, phaseulous bean and soybean. However, the agricultural economic expansion of the RGE will continue over the next few years due to its location, its minimum available infrastructure, availability of alternative technological packages, the increases of the Brazilian food demand and the large area of natural "Cerrado" which is appropriate to agricultural production, Franz et al(1985).

The Brazilian policy makers have recently stressed the importance of agricultural policies that promote increases in maize, rice, cassava and phaseulous bean crop yields.

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[2]Basically, the ecological reserve law establishes that no more than 80 percent of the land area of a farm can be commercially used. However, the institution responsible for its application does not yet possess sufficient material resources or qualified personal to enforce this.
[3]Forestry crops were not included but they were not significant anyway.

The maize and phaseulous bean crop yields in the RGE are indeed very low as is shown in Table 3.2. However, many small farmers, tenant or "agregados" in the RGE develop their maize and phaseulous bean crops in a indigenous way without any fertilizer or improved seeds.

Table 3.2 Crop Yields in the RGE in 1984.

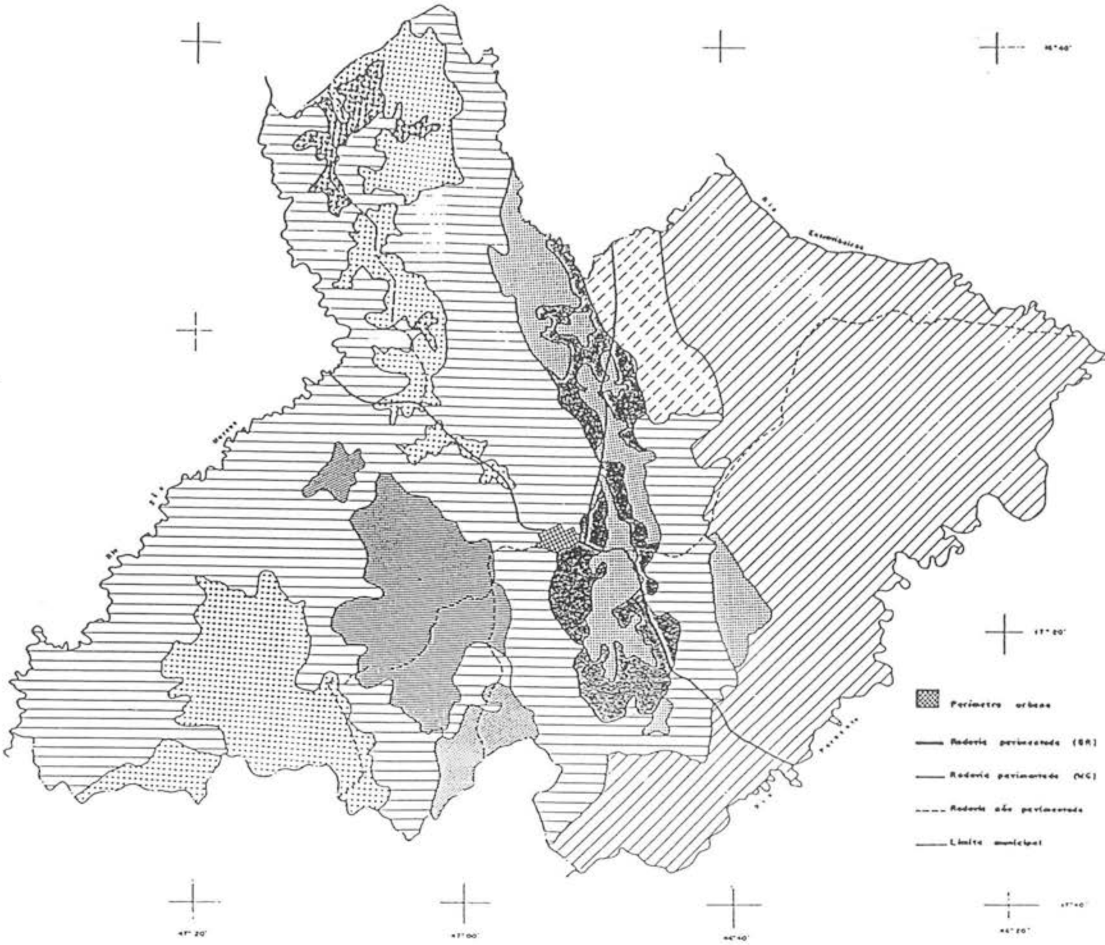
Crop	area (ha)	production (tonnes)	yield (kg/ha)
rice	61,958.	80,210.	1,103.
phaseulous bean	62,926.	35,490.	564.
maize	94,333.	212,910.	2,257.
soybean	52,373.	77,250.	1,475.
wheat[(a)]	2,879.	2,240.	778.

Source: Franz et al(1985) " Regiao Geoeconomica de Brasilia: Caracterizacao do Setor Agropecuario", Planaltina - DF, Brazil.
ha - hectare
kg - kilogram
(a) Wheat crops without irrigation present high production risks.

3.5 The Case Study Area

Taking the RGE as representative of the "Cerrado" region, the selection of a natural vegetation land area in the Paracatu district has been indicated because of the availability of some essential data, and also, it has been the subject of other studies by EMBRAPA. Such an area is located in the "Planicie do Rio Paracatu" (267,100 hectares) area illustrated in Map 3.2.

Franz(1989) stresses that the "Planicie do Rio Paracatu" covers about 34.8 percent of the Paracatu district but it does not include more than 20 percent of the its farms due to large latifundiums. He also shows that some commercial crop farms which have been implanted in the Paracatu river basin (by PRODECER and PROFIR programs)



UNIDADE MORFO PEDOLOGICA	GEOLOGIA	PERFIL ESQUEMÁTICO	HIDROGRAFIA	VARIAÇÃO DE ALTITUDE	VEGETAÇÃO NATURAL	SUPERFICIE	% MUNICIPAL	USO ATUAL	% MUNICIPAL DE OCUPAÇÃO	OBSERVAÇÕES E RECOMENDAÇÕES
PLANÍCIE DO RIO PARACATU	Sedimentos detríticos de origem coluvionar e aluvionar [illegible]	Cx LE LV	Densidade média / baixa, drenos perenes, longos e meandrados / Densidade média/alta, drenos perenes e médios	500 - 600 m	Cerrado denso e cerrado típico. Mata ciliar e campos hidromórficos	[illegible]	[illegible] %	80 % com vegetação natural, sendo 60% com cerrados e 20% com campos. 20% restantes com lavouras e pastos, cultivados com alta tecnologia	15 %	Chuvas concentradas. Solos [illegible] Latossolos de [illegible] fertilidade e alta acidez. Boas perspectivas de irrigação. Área apropriada para ocupação agrícola de alto índice técnico. Parcelas de 300 a 400 ha.
PLANÍCIES INTRAMONTANAS	Sedimentos detríticos de origem coluvionar [illegible]	LE LV Cx	Densidade média/baixa, drenos perenes, longos e meandrados	550 - 700 m	Cerrado denso e cerrado típico. Vereda c/ buritis e mata ciliar. Campos	[illegible]	[illegible] %	85% com vegetação natural. Os 15% restantes com lavouras [illegible], com alta produtividade, [illegible] com pecuária e lavouras de subsistência	10 %	Chuvas dispersas. Solos de baixa fertilidade e alta acidez. Perspectivas de irrigação mediana. Requer [illegible] de conservação. Área apropriada para ocupação agrícola de alto índice técnico. Parcelas de 300 a 400 ha.
CHAPADAS RESIDUAIS	Sedimentos detríticos [illegible]	LE LV Cx	Densidade baixa e [illegible]. Drenos perenes e longos	> 900 m / [illegible] - 900 m	Cerrado típico. Cerrado denso / Campos. Mata ciliar	[illegible]	[illegible] %	50 % com vegetação natural. 45 % de ocupação [illegible], com reflorestamento, café, [illegible] e arroz / 5 % restantes em pecuária também [illegible]	25 %	Chuvas dispersas. Solos de baixa fertilidade e alta acidez. Poucas possibilidades de irrigação. Requer [illegible] de conservação. Áreas apropriadas para ocupação agrícola de alto índice técnico. Parcelas de 300 a 400 ha.
COLÚVIOS SERRANOS	[illegible]	[illegible]	Densidade baixa, drenos perenes e longos	600 - 700 m	Mata	[illegible]	[illegible] %	30% com vegetação natural. Os restantes 70% estão divididos entre lavouras de subsistência, [illegible] e pecuária	35 %	Chuvas dispersas. Solos de [illegible]. Boas possibilidades de irrigação. Requer [illegible] de conservação. Área apropriada para ocupação agrícola de baixo índice técnico. Parcelas de 40 a 60 ha.
SERRAS CALCÁRIAS	Formação [illegible] Calcários e dolomitos [illegible]	[illegible]	Nascentes	700 - 900 m	Mata	[illegible]	[illegible] %	Praticamente sem uso, a não ser por pequenas extrações de calcário para corretivos	zero	Própria para reservas
RELEVO DISSECADO	Grupo Canastra [illegible] ardósias, filitos e quartzitos dobrados [illegible]	Cx LV LE LV LE LV	Densidade alta, drenos [illegible], perenes e intermitentes, curtos e [illegible]	[illegible] - 900 m	Campos. Cerrado típico e cerrado ralo. Mata	[illegible]	[illegible] %	95% no estado nativo, com 80% de campos. Cerca de 5% apresenta-se ocupado com pastagens cultivadas e lavouras de subsistência	15 %	Região de terrenos [illegible], [illegible] limitada e imprópria para mecanização. Área apropriada para ocupação agrícola de alto índice técnico em reflorestamento e pecuária de corte

Map 3.2. - Paracatu District Areas and its Relief, Soils and Vegetation
Souce: Carneiro (1986) "Metodo Sumario de Avaliacao e Interpretacao de Dados Ambientais Aplicado ao Planejamento Agricola.", EMBRAPA/CPAC, Planaltina - DF., Brasil.

introduced irrigated crops as wheat, tomatoes, dry peas and crops for the first time in the district area.

However, the object of this study is the "Cerrado" natural vegetation area which covers 74 percent of the "Planicie do Rio Paracatu" and presents available water for new irrigation scheme, good topografy and large area of arable soils and it is relatively near to the Brasilia capital market.

3.6 Paracatu District

3.6.1 General definition

Paracatu city is located 220 kilometres from Brasilia (the Brazilian capital) and 560 kilometres from Belo Horizonte (the state's capital). More specifically, its geographic position is 46^0 52' 29'' W longitude, and 17^0 13' 20'' S latitude. Its altitude is 687 metres.

The Paracatu district covers an area of 7882 km^2. It consists of six distinct (in terms of relief, soil and vegetation) areas which are identified in the Map 3.2, Carneiro(1986). These are:

- "Planicie do Rio Paracatu" or the "Planicie" area which covers 267,100 (33.9 percent) hectares at an altitude between 500 and 600 metres. Its "latossolos" are appropriate for agricultural production. In 1986, about 13 percent (35,000 hectares) of the total "Planicie do Rio Paracatu" area was occupied by commercial crop farms (10 percent of crop land and 3 percent taken for ecological reserve), 13 percent by forestry crops, and 74 percent by "Cerrado" natural vegetation.
- The "Planicies Intramontanhas" area covers 60,000 (7.6 percent) hectares of the district area at an altitude

between 550 and 700 metres. In 1986, about 15 percent of "The Planicies Intramontanhas" was occupied by commercial and subsistence farms (13 percent being commercial and indigenous crops and cultivated pastures and 2 percent taken for ecological reserve) and 85 percent by "Cerrado" natural vegetation.

- The "Chapadas Residuais" area covers 97,100 (12.3 percent) hectares of the district area with altitude all over 850 metres. In 1986, about 20 percent its area was occupied by cultivated forestry (20,000 hectares), 17 percent by upland rice, soybean, maize, coffee and other crops and 60 percent of "Cerrado" natural vegetation.
- The "Coluvios Serranos" area covers 35,100 (4.5 percent) hectares of the district area at an altitude ranging between 600 and 700 metres. In 1986, 70 percent of its area was occupied by indigenous crops and extensive beef cattle production systems and 30 percent of "Cerrado" natural vegetation.
- The "Serras Calcarias" area covers 38,900 (4.9 percent) hectare of the district area. Here, the altitude varies between 700 and 900 metres. This area is not appropriate for agricultural production due to its relief. However, some lime has been produced in this area.
- The "Relevo Dissecado" area covers 290,200 (36.0 percent) hectares of the district area with an altitude between 680 and 900 metres. In 1986, about 5 percent was occupied by indigenous crops. However, it is not appropriate for agricultural purposes due to its relief. Forestry would be a good option.

Extensive beef cattle farm systems were established many years ago in the all "Cerrado" natural areas described above.

3.6.2 Economic and social organization

From a Paracatu urban population of 29,877 in 1980, no more than 8600 people were working and about 30 percent were children of less than 10 years old. The number of houses and other buildings in Paracatu city was 11,678 in 1980, no more than 3,832 having electric power.

The Paracatu rural population was 19,133 (about 40 percent of the whole district population) in 1980 and at that time 7,797 people (labour force) over 10 years old were farming. In 1985 the number of people that constituted the rural labour force was upwards of 10,004 as is shown at Table 3.3.

The recent socio-economic changes in the Paracatu district have been marked by a gold mine (which is polluting water streams) and new commercial crop farms implanted (at the "Chapadas Residuais" area illustrated at the Map 3.2) by the PRODECER agricultural program. Consequently, in 1982, the Paracatu district produced 256,800 tonnes of charcoal (for steel industries located in the Belo Horizonte industrial district), 12,650 tonnes of fire wood used to produce energy in some houses and 27,450 tonnes of wood, FIBGE(1988).

In 1985, as is shown in the Table 3.3, the land area owned by about 10 percent of the Paracatu farmers covered over 60 percent of the district area. However, in 1986, such land area was used to implant the new commercial farms mentioned above. One positive aspect of these new commercial crop farms in the "Chapadas Residuais" is the economic use of 5 larger unproductive latifundium, (Vilela 1988, pers. com.). One negative aspect of such a project refers to the low utilization of the rural labour force (379 people) that was associated with those latifundium. Possibly, one of the explanations is that the indigenous labour force did not adjust to new mechanical production systems. Another explanation refers to changes in the relations[4] between the landlords and the farm workers. These aspects must be considered in any rural development project and in this particular case a specific study about the impact of the new crop farms on the Paracatu rural socio-economic organization, would be useful in proceeding towards the necessary adjustments. Also, such a study would constitute relevant information for new rural development projects in the "Cerrado" region.

The number of illiterate people in the Paracatu district is about 30 percent of the whole population SUDECO(1985). This has occurred due to the poor social infrastructure (such as schools and health services) in its rural areas, which is a consequence of none integration of the poor people in the development process.

Table 3.3 Agricultural Production in Paracatu District - 1985

Farm size	farm	total	la-	trac-	crops[a]		animal production		
	number	area	bour	tor	tree	annual	beef	swine	thicken
(ha)	(un)	(ha)	(pp)	(un)	(ha)	(ha)	(un)	(un)	(un)
1> 10	41	255	!!!	2	31	95	215	410	1433
11> 100	566	25204	2708	43	498	4053	13961	3367	153947
101> 200	225	32329	1210	65	268	4859	12446	1716	10737
201> 500	302	100364	2019	274	1369	23192	26335	2824	134107
501> 1000	149	102171	1295	149	231	11774	31501	2045	9103
1001>10000	152	354538	1856	349	500	25329	71923	3362	9110
>10000	5	66766	379	60	330	3830	4498	30	80
not included	80	47497	537	30	!!!	!!!	4882	68	510
	1520	729124	10004	972	3227	73132	165761	13822	265269

"Source: "Fundacao Instituto Brasileiro de Geografia e Estatistica"- (FIBGE) Brasilia - DF
[a]Forestry crops were not included.
(ha): Hectare.
(unt): Unit.
(pp): People.
(!!!): Under-estimated value.

3.6.3 Basic infrastructure

[4]Due to the land tenure legislation and cultural aspects.

The Paracatu district, as a raw material exporter has a minimum of basic infrastructure: transport, storage, telecommunication, banks, co-operatives, a large number of small commercial shops and some precarious public services (such as: schools, agricultural extension, hospitals). Most infrastructure is located in the Paracatu city.

3.6.4 Soils, topography and climate

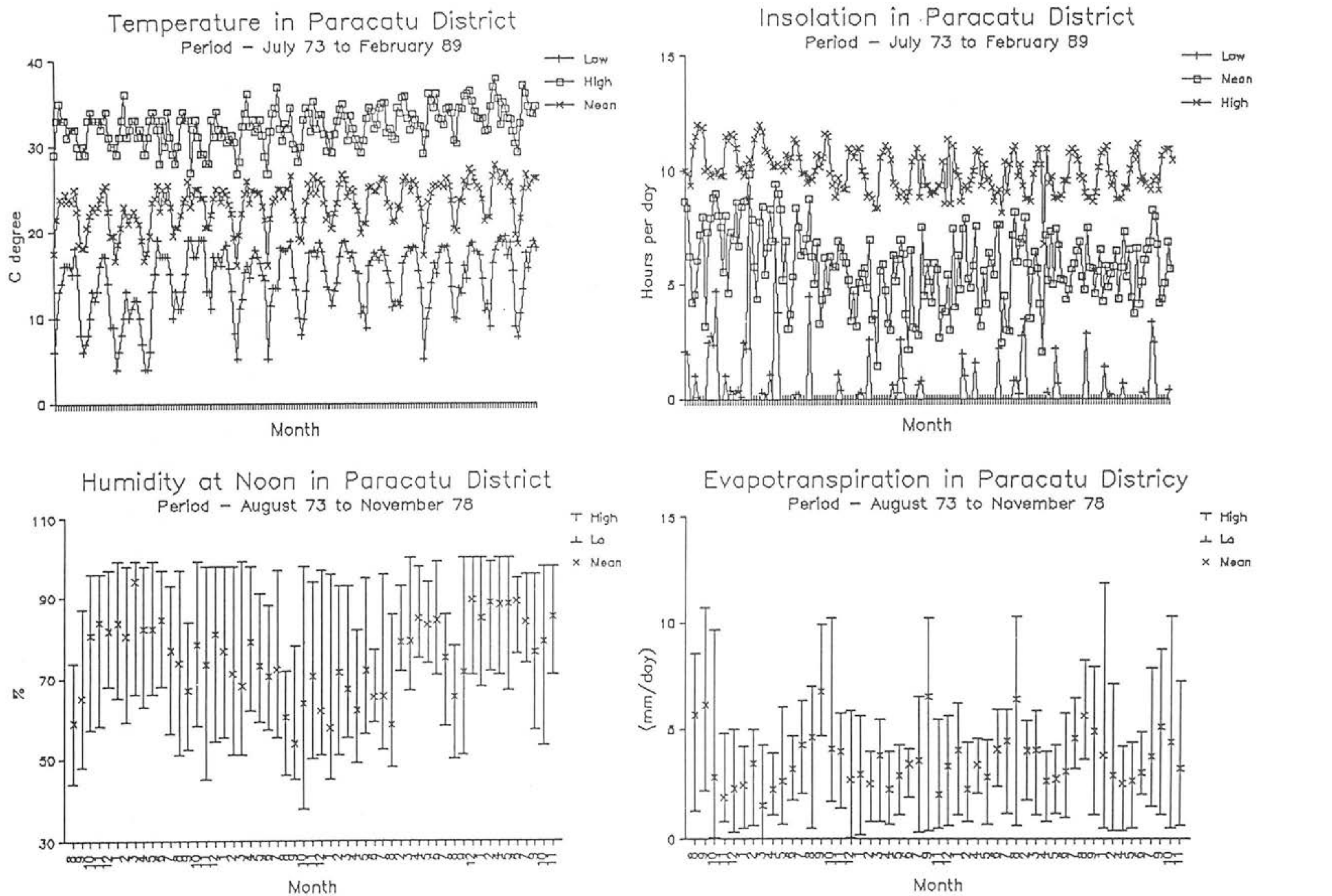
The Paracatu district has most of the "Cerrado" soil types described in the Table 3.1. However, "areias quartzosas" or quartzipsaments soil type which is inappropriate for agricultural production due to its physical structure, is not identified, and the area having a low slope topography is large.

The Paracatu district climate, as in other "Cerrado" areas, is characterized by two defined periods: the rainy season in the period October to April, during which more than 90 percent of the rains fall(which can be over 100 millimetres per day or over 40 millimetres per 30 minutes), and the dry season in the period May to September. Figure 3.1. and Table 3.4 presents some information of the Paracatu city climate.

Garrido et al(1978) stressed that heavy rains associated with sparse vegetation and permeable soils generate an intensive erosive activity on the "Cerrado" soils. This problem has been identified on some Paracatu commercial crop farms.

Although the "Cerrado" region experiences extensive rainfall, variable periods without precipitation (locally known as "veranicos") frequently occur during the rainy season. A "veranico" can be over 20 days long. There

Figure 3.1 Climate Information of the Paracatu City



can be as many as three "veranicos" during a rainy season each with different durations. These "veranicos" can be critical for all crops.

3.6.5 The land use and ownership

In 1985, the land use and ownership situation in the Paracatu district was as shown in Table 3.3. Its latifundium (farms over 1,000 hectares) represented 10.32 percent of the 1,520 farmers but occupied 57.78 percent of the total land area. The cultivated area in the Paracatu district covered 55,000 hectares of forestry crops and 76,359 hectares of annual crops which represent 17.1 percent of the total area. The total annual crop area included among others, the following: 22,978 hectares of rice crops, 7,000 hectares of maize crops, 29,000 hectares of soybean crops, 4,075 hectares of phaseulous bean crops, 45 hectares of wheat crops.

Table 3.4 Monthly Rainfall Data of the Paracatu City

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	total
73							0.0	0.0	34.2	157.3	211.5	83.0	
74	108.0	80.2	438.1	91.1	14.4	0.0	0.0	2.6	0.0	98.7	35.4	110.1	978.6
75	140.2	176.8	13.0	70.0	62.0	0.0	4.1	0.0	1.3	111.0	364.4	97.8	1040.6
76	50.7	220.5	92.7	1.3	48.0	0.0	19.0	0.2	36.1	139.1	148.8	158.7	915.1
77	226.9	11.1	80.3	93.5	8.2	2.9	0.0	0.0	35.9	139.3	146.3	141.9	886.3
78	188.4	186.1	155.3	68.1	102.9	2.0	22.0	0.0	8.7	98.8	138.3	239.9	1210.5
79	537.9	272.4	132.8	41.3	69.0	0.0	0.0	13.3	21.6	95.7	202.9	309.6	1696.5
80	387.4	197.8	5.4	177.6	1.1	0.0	0.0	0.0	47.1	34.4	213.0	272.7	1336.5
81	386.4	77.6	234.0	46.5	17.5	44.8	3.4	19.2	0.0	417.3	220.2	254.4	1721.3
82	383.8	17.4	539.7	41.6	47.5	0.0	2.2	0.0	23.1	96.2	123.9	153.2	1428.6
83	686.0	342.4	221.3	230.8	34.5	4.4	22.1	0.0	46.0	321.3	278.5	431.4	2618.7
84	109.1	94.2	146.9	52.4	0.0	0.0	0.8	39.6	40.9	60.6	162.1	421.9	1128.5
85	584.0	144.7	200.3	22.5	28.8	0.0	0.0	0.0	55.2	49.9	271.2	287.1	1643.7
86	341.6	225.8	28.3	1.6	42.5	0.0	39.0	117.9	7.2	24.6	110.0	334.7	1273.2
87	264.5	73.5	78.9	65.2	1.4	3.3	0.0	0.5	76.4	162.7	234.6	372.5	1333.5
88	152.7	167.9	163.8	158.4	3.0	2.2	0.0	0.0	2.7	131.9	141.9	231.3	1155.8
89	131.7	270.0											

Source: Instituto Nacional de Meteorologia (1989) - Brasilia - DF, Brazil.

From 1982 to 1985 the number of beef cattle herds in the Paracatu district was increased by 15 percent and soybean crop area was increased by about 101.4 percent. However, at the same period the indigenous phaseulous bean crop area decreased by 27 percent. One of the reasons for this, in the opinion of local advisers, is that large areas of soybean crops have brought new phaseulous bean crop pests.

Eucalyptus and pines trees have also been cultivated in a few large areas in the Paracatu district. In 1982, eucalyptus tree crops covered 35,657 hectares and pines covered 9,753 hectares. Most of these were in the "Chapadas Residuais" area (Map 3.2).

Chapter 4 Approach, Methodology and Source of Data

4.1 The Nature of the Planning Problem

4.2 Research Approaches for Farm and Regional Development Planning

4.2.1 Whole farm-firm planning approach

4.2.2 Regional planning approach

4.3 The Chosen Research Approach

4.3.1 Modelling at the farm level

4.3.1.1 The simulation crop models

4.3.1.2 The price forecasting models

4.3.1.3 The multi-period mixed integer programming model

4.3.2 Modelling at the regional level

4.4 The Source of Data

4. Approach, Methodology and Source of Data

Systems research presents an opportunity for placing narrowly focused research in a broader perspective and consequently it is fundamental to a study of the use of agricultural resources such as "Cerrado".

This study is therefore conducted from a systems viewpoint[(1)]. A network of relations from the crop development process level to the socio-economic environment of the farm and regional levels defines the boundary of the system to be studied. Such network considers the identity , the organization of the system as well as referring to the various levels of goals and achievements required.

This chapter presents the following aspects:

- .The nature of the planning problem;
- .Research approaches for farm and regional development planning;
- .The chosen research approach; and
- .The source of data to be used.

However, given the restriction of space and specific interests, the second point is presented as a brief review of existing techniques of farm management and other relevant scientific areas.

4.1 The Nature of the Planning Problem

" An important difference between agricultural

[(1)]The "systems approach" has been portrayed by Rapoport(1986) as a counter-current to the increasing fractionation of science into highly specialized branches resulting in a break down of communication between the specialists. For him the word system already suggests an awareness of inter-relatedness of parts, from which a whole (sum of its parts) acquires its own existential properties independent of those of the parts.

> projects and projects in other economic sectors is the biological nature of agricultural pursuits making it harder to predict input-output relationships." Benjamin (1985, p22).

The difficulty of predicting agricultural capacity with regard to the region under study has significant implications for estimation of the impacts of development programs.

In recent years considerable effort has been directed towards economic development in the Midwest of Brazil, and has been associated with subsidised agricultural investment projects to expand new agricultural areas in the "Cerrado"'s region. Consequently, more than three million hectares of "Cerrado"'s soils have been effectively incorporated into the Brazilian agricultural production process.

Such projects were part of regional economic development programmes which emphasized other investments such as: new roads, storages, electric power, and agricultural research. However, although such programmes have yielded effective results in terms of agricultural production in areas of acid soils, and improvement of the basic infrastructure in the region, they have been criticized for failing to improve the economic and social well-being of the majority of the local rural people. A small number of people have captured a disproportionate share of both the economic and political gains generated by the programmes.

In the 1970s, a Brazilian programme called POLOCENTRO, was implemented in a context in which economic growth was the crucial objective. It did not emphasize the participation of a large number of small farmers of the local (Midwest) region or any effective measure to deal with the environmental impacts of new agricultural technologies. This programme has been evaluated by Ferreira(1985) who has suggested three basic points for reorientation of Brazilian regional development programmes. These are: the promotion of small farmers, introduction of specific land tenure actions, and institutional reforms to support such programmes.

In January 1985, Momma(1985) presented an analysis of the subsequent "Cerrado" agricultural development programme - PRODECER II which is orientated to the development of commercial farms in specific sub-regions of "Cerrado". Such commercial farms which vary from 300 to 500 hectares, have required around US$ 1400 subsidised agricultural credit per hectare for their implementation. For a typical croping farm of 400 hectares, Momma(1985) showed that the project was financially feasible from a societal perspective.

In March of 1988, Momma(1988) outlined the objectives of PRODECER II of the Brazilian Government as follows:

(i) increasing the food and agricultural raw material regional supplies in a competitive way;
(ii) job generation with better conditions in the rural area;
(iii) improving relations between the rural area and city by the generation of a rural middle class and formation of new leaders in the rural area;
(iv) pilot projects to demonstrate and diffuse new agricultural technologies;
(v) incentives towards cooperativism.

The participation of farmers in the PRODECER II programme is through cooperatives. However, this programme does not include an integrated rural development component which is essential to any large-scale regional development effort in Brazil or elsewhere.

The present study is being developed as a consequence of past development experiences and unanswered issues which involve, for example:

. The high capital requirements for implementation of productive farms on the poor "Cerrado" soils, which have been supplied by the Government without detailed studies on their efficiency in economic, social, and ecological terms;

. Low number of farmers involved;

. High risks involved in "Cerrado" agricultural production of staple food[2];

. Incomplete[3] farm management procedures;

. Unestimated ecological impacts of new technological packages (e.g. "...when genes or machines foreign to the farm are enboided in the changed technology", Anderson and Hardaker(1979, pg 12);

. Application of ecological reserve laws;

. Lack of public participation which can be realized without revolutionary changes in the existing political and economic order. An integrated rural development programme must enable rural communities to mobilize their own resources to generate growth and improve the quality of life of the local people.

The crucial issue in this study, is to determine the minimum capital requirement for implementing a sustainable[4] crop farm in the "Cerrado" region. Other important issues in the Brazilian rural development problem not specifically addressed in this study are:

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[2]Staple food such as rice and maize.

[3]The farm planning procedures used by Brazilian agricultural advisers rely on simple budgets without risk assessment and very limited use of farm specific information.

[4]Sustainability of a farm system has been referred by Redclift(1987) as the

> "ability to maintain productivity in face of a major disturbance, such as that caused by soil erosion, farmer indebtedness, an unanticipated drought or a new pest."

- Product price policies by the Government;
- Land tenure and the Brazilian agrarian reform needs;
- High costs of obtaining in-field agricultural trial results for specific localities which are relevant in selecting well defined technological packages;
- The utilization of the relatively low quality (and inexperienced) human resource endowments that are available in rural areas;
- The recent interest of the Brazilian Government in micro-hydrographic development; and
- The demand for staple food in the near future in Brazil which will continue to increase as a consequence of population growth and, possibly, better income distribution, (Alves and Contini,1988).

4.2 Research Approaches for Farm and Regional Development Planning

In general, farm development planning has been studied as a firm growth issue where the principle of growth as defined by Irwin(1968) is

> " to acquire control of the services of additional productive resources by paying a price less than they will earn ".

However, farm growth is concerned also with a process of obtaining funds to purchase these resources (either internally or from external sources) which depends on family consumption levels, profitability of the business, price and yield variability, lender attitudes, tax management and other factors as shown by Beck(1984).

Growth theories for managerial direction of agricultural firms have been reviewed by Renborg(1970). For him, firm growth involves increases in size[5] by

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[5]Size is

> " some measure of the total sum of all the means of production which the firm commands ", Renborg(1970)

" a process in time where the decision maker selects growth directions according to some goals."

And, goals such as:

" (i) making withdrawals of specified amounts of cash, goods and services;

(ii) making withdrawals of leisure time;

(iii) ensuring an amount of savings necessary to guarantee the future withdrawal of cash, goods, services and leisure time; and

(iv) keeping risk and uncertainty within such limits that the decision maker thinks the firm's future existence is guaranteed",

are likely to be of interest to decision makers (farmers).

Some farm growth case studies have followed behavioural theory by using dynamic simulation techniques, Patrick and Eisgruber(1968), Chalton(1972), Harrison and Longworth(1977). Thirty years ago, Cyert et al(1959) showed that a relatively complex simulation model[6] of a firm as a decision-making organisation could be developed and used to yield economically relevant and testable predictions of business behaviour. However, many farm growth problems have been attacked by mathematical programming methods[7] which allow, among other things, the integration of investment and financial theories in a simple way, Renborg(1970).

In reviewing the research programs in quantitative modelling developed by the Australian Bureau of

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[6]A model is defined by Voorhees(1987), as

" a rationally constructed methaphor of a system or of one of its components, used as a tool for analysis, (pg 103)."

[7]A method is defined by Voorhees(1987) as

" a rational algorithm which prescribes a set of procedures whose implementation constitutes a process resulting in a specific empirical result. (pg 103)"

Agricultural Economics (BAE), Kingma et al(1980) have reported that farm models have been used:

" (i) to explore the influence of price and output variation on farmers' operations and income streams over time;

(ii) to examine the ability of various types of farms to cope with economic pressures overtime; and

(iii) to assess the impact of constraints on expansion of the sheep meat enterprise. "

However, in spite of this, they suggested that much could be done to improve the specification of technical and behavioural relationships within the models and to conduct analyses of a validatory nature.

The important theoretical contributions for farm firm growth studies presented by Irwin(1968), Renborg(1970) and Ockwell(1974) have been expanded in this thesis to a broad viewpoint where farm development planning must be integrated in a rural development process, which, in terms, must be conceptualised at regional, state and national levels. This last viewpoint has been supported by Goodman(1984) and by more recent studies carried out by Hardaker et al(1979), McGregor(1986), Faber(1986), and Beck and Dent(1987).

4.2.1 Whole farm-firm planning approach

The farm-firm has been conceptualised by Ockwell(1974) as consisting of a number of subsystems which include the functions of production, marketing, insurance, taxation, investment and consumption. The link between these subsystems is provided by a financial subsystem which is involved in the acquisition and use of capital resources by the individual farm-firm. The financing of on-farm investments may be accomplished through funds internally generated by the farm-firm, through external sources of funds, or a combination of the two.

The choice among alternative actions involving any farm-firm subsystem

> "need to be assessed in terms of their effects on the financial position of the farm-firm in some future time period",Ockwell(1974).

The analyst must also include the effects of farm-firm exogenous variables in the decision-making process, (Thornton and Dent(1987)).

There are a range of techniques available for whole farm-firm modelling. Anderson and Hardaker(1979) discuss some techniques to analyse new technologies for small farmers and conclude the following:
Simple whole farm models, whether in the form of budgets or in some other form, are relatively easy to use. They are not very demanding of special analytical skills and so, can be used by extension workers. Nevertheless, the use of increasingly complex whole farm models is justified where the problems addressed by a given study require more information than a simple elicitation of broad effects which are given by using a simple technique.

4.2.2 Regional development planning approach

Regional plans can emphasize either single and/or multi-purpose development. They are designed for a defined geographic area over a specific period of time.

Rural regional planning often includes a number of different projects and may encompass both structural and nonstructural elements. So, in rural regional planning studies, the term integrated planning is often applied, Ruttan(1984).

Discussing comprehensive or integrated regional planning Goodman(1984) describes that in USA, water and land resources plans

> " often include a schedule ... sufficient information ... controlling parameters (such as dam elevation, capacities, etc) .... They may also include concise statements or tables summarizing contributions to specific planning objectives and project impacts (economic, environmental, social and others), (pg 159)."

Recent regional development programmes in Brazil have been conceptualised in a top down way due to the long period (1964 to 1985) of dictatorship. Consequently, the POLOCENTRO program for example did not result from a comprehensive planning approach such as described by Ruttan(1984), Goodman(1984) and McGregor(1986). The POLOCENTRO and Carajas development programmes have been criticised by Ferreira(1985) and Treece(1989) emphasizing economic development above other objectives.

Furthermore, despite significant increases in production by some of the Brazilian "Cerrado" agricultural development schemes, there is now growing concern over technologies dependent on hazardous and nonrenewable inputs which result in serious soil erosion problems, and in other environmental impacts such as infilled rivers with sedimentation.

Mathematical modelling is a frequently used tool in modern water and land resources planning and management, Goodman(1984). Detailed reviews of different techniques - useful to analyse multiobjective/multipurpose planning problems - have been presented by Cohon(1978), Goodman(1984), McGregor(1986), Romero and Rehman(1989) and Berdegue _et al_(1989). The above authors discuss advantages and disadvantages of various categories of mulpitle objective programming(MOP) techniques, including dynamic simulation and other methodologies that emphasize objectives which are not quantified in monetary terms.

McGregor (1986) mentions that although a large number of modelling approaches have been tested in analysing water and soil problems by academic researchers, only a few of them have been used in applied situations. He has developed a multiple objective planning framework and shows that in formalising the analytical structure within which decisions about resource management are to take place, MOP techniques have a place.

Goodman(1984) describes an interesting application of simulation techniques in a study prepared for the United Nations on the integrated development of a specific geographic area in Europe (Vardar/Axios River basin in Yugoslavia and Greece). A set of twelve different simulation models were developed and used as tools in the integrated planning of single and multipurpose projects to meet various regional needs, (pg 162-164). When adequate (data, time, money and human) resources are available to carry out studies of large projects, simulation techniques represent a suitable planning tool that allows the effect of numerous "what if" options to be analysed interactively, McGregor(1986).

4.3 The Chosen Research Approach

At the beginning of this chapter it was emphasised that the systems approach has been chosen to orientate this study. Klein and Sonntag(1982) have outlined that modelling from a systems perpective

> "clarifies and organises thoughts about components of the production system, ... enforces a concern

> for all conponents of the problem,... draws attention to interactions among components (e.g. enterprises or resources) that otherwise are often ignored, and
> ... permits the testing of hypotheses", (pg. 42).

McGregor(1986) has stressed that the choice of modelling techniques has been generally left to the interests and skills of the analyst(s) or modeller(s) or researcher(s). He also mentions that in selecting a research methodology the analyst must consider the suitability and/or cost effectiveness of each of the possible approaches.

Within this study, the choice of appropriate techniques, definition of the systems boundary and systems components at farm and regional levels occurred after consideration of

. the time available for the study;
. the availability of data;
. the availability of basic software;
. the availability of existing models[8];
. the computational viability and possibilities of alternative modelling approach[9] relevant to this study.

The interrelations between the models selected to perform this study are included in Figure 1. A hybrid model structure was adopted whereby crop yields and prices are predicted to provide inputs into a farm level MOTAD mixed integer, multiple period linear program. Outputs from the farm level model in turn are used to drive a multiple

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(8)Models such as crop simulation models which were validated and presented the possibility to be transported to other situations.

(9)Pure simulation modelling approach and approach combining mathematical programming and simulation techniques outlined by Beck(1984), and another approach combining simulation and expert systems techniques in development by Thornton and Dent(1987, per. com.).

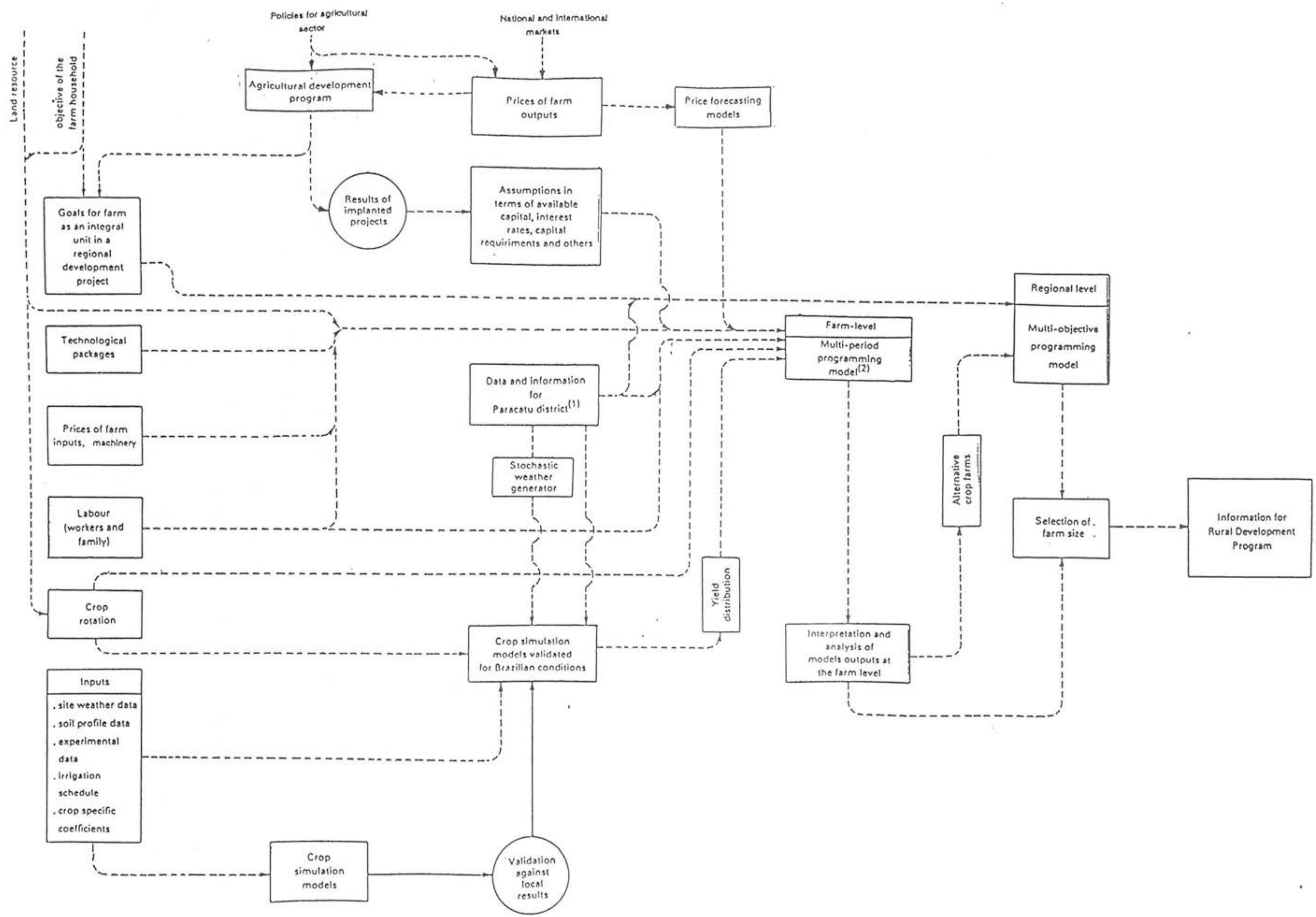

Figure 4.1. A Conceptual Modelling Framework for "Cerrado" Agricultural Systems
(1) Data and information such as: site weather data, soil profile data, cultivars genetic coefficients, availability water for irrigation and land areas.
(2) The conceptual whole farm system model is described in the Figure 6.1..

objective goal programming model that is used to assess regional issues. The models work independently, and are controlled by the analyst. The adopted modelling framework was considered by the writer to represent a suitable ex-ante agricultural development projective appraisal tool.

4.3.1 Modelling at the farm level

At the farm level, four crop (wheat, rice, maize and soybean) simulation models are included. These models were developed by IBSNAT[10]. Daily weather variables (precipitation, maximum temperature, minimum temperature and radiation) are required as inputs for the crop models and are generated by the WGEN[11] model. Predicted crop yield distributions and monthly product prices are incorporated into two alternative mixed integer linear programming MOTAD formulations[12].

4.3.1.1 The simulation crop models

The dynamic and stochastic characteristics of the crop production process are incorporated using IBSNAT crop simulation models. IBSNAT models were incorporated to generate crop yield distributions in a suitable form for use within the farm model. Local data from experiments or surveys will never allow development of suitable yield distributions. Jones and Kiniry(1986) have presented details of one of these models. The CERES maize model has recently been updated by IBSNAT project. The complete documentation of the other crop models used, is being prepared by IBSNAT project(1987). These models

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(10)The International Benchmark Sites Network for Agrotechnology Transfer (IBSNAT).
(11)WGEN is a weather generator simulation model developed by the United States Department of Agriculture (USDA), Richardson and Wright(1984).
(12)A standard version with expected crop yields and a risk version which includes the MOTAD formulation.

have already been tested and validated through a succession of formal and informal tests and under varying conditions in the USA and Europe. However, their applications for Brazilian conditions require further validation which is discussed in chapter 5.

4.3.1.2 The price forecasting models

In management decision making processes, from an entire economy to that of an individual firm, forecasting is one of the most important elements because the ultimate effect of any decision almost invariably depends upon factors whose outcomes are unknown at the time the decision is made.

Chatfield(1984) has classified the many types of forecasting procedure into three broad categories:

i) Subjective - "Forecasts can be made on subjective basis using judgement, intuition, commercial knowledge and any other relevant information".

ii) Univariate - "Forecasts can be based entirely on past observations in an given time series by fitting a model to the data and extrapolating."

iii) Multivariate - "Forecasts can be made by taking observations on other variables into account."

However, the practice of forecasting may involve a combination of the above approaches.

In reviewing the development of forecasting techniques, Rogers(1977) has discussed econometric methods, time series methods and leading indicator methods. He describes that econometric models are best suited to conditional forecasting, i.e. to answering "what ...if...?" and time series models are suitable for unconditional forecasting, (e.g. "what will be the farm gate price for soybean in May of 1990?")

In this study univariated forecasting procedures have been used to forecast monthly product prices. The methodology adopted to forecast prices for wheat, rice maize, and soybean are briefly presented in Appendix 2.

4.3.1.3 The multi-period mixed integer programming model

In order to permit expression of whole-farm development involving consideration of likely crop yield variation and investment activity, a multi-period integer programming model (CECROPF) was formulated to incorporate MOTAD, Hardaker <u>et al</u>(1984). For more complete discussion of the method by which yield data were generated for use within the CECROPF model, refer to Appendix 4. Also associated with the mixed integer programming framework, are forecasting models that predict product prices on monthly basis. Plans derived From the CECROPF model are considered by the writer to provide a useful basis for studying the "Cerrado" investment problem, (see Chater 6).

4.3.2 Modelling at the regional level

At the regional level multiobjective modelling allows a better choice among alternative farm systems selected at the whole farm modelling process.

The MOP approach was chosen considering its applicability for the purpose of this study. Specifically the lexicographic goal programming (LGP) technique[13] which relies on prior articulation of preferences has been selected following Cohon(1978), McGregor(1986) and Romero and Rehman(1989). It is well known, widely used and available in reliable software, Lee(1972) and Bartlett <u>et al</u>(1976).

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[13]"In LGP, higher priority goals are satisfied first it is only then that lower priorities are considered, hence, the lexicographic order", Romero and Rehman(1989, pg 36).

4.4 The Source of Data

Availability of data is an important consideration in modelling. Baker and Curry(1976) have outlined that it is part of the problem formulation step of model building and data sources should be located and their adequacy evaluated early in the model building sequence. However, the extent of the data collection difficulties are not easily identified when different data sources and peoples are involved.

This study is being conducted under insufficient reliability of important basic informational inputs, as is often the case in many practical farm planning applications in underdeveloped countries.

Given the extent of the modelling framework described above, the following data and information are required:

- Paracatu's weather time series (15 years of daily data) supplied by INEMET (in Brasilia) for generating data wether variables;
- Experimemental data from a CPAC[14] data base to adjust[15] the crop simulation models for the "Cerrado"'s condition;
- Monthly farm product prices organized in four different time series described in the Appendix 2. Such data were supplied by "Comisao de Financiamento da Producao" (CFP) (in Brasilia);
- Budget estimates by advisers from Brazilian extension services and data and information from a case study

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[14]"Centro de Pesquisa Agropecuaria do Cerrado" (CPC), Planaltina -DF, Brazil.

[15]Given that some of the crop simulation model inputs (described in the Appendix 3) were not measured by the Brazilian research stations, some educated guesses were used as the last option in the adjustment processes of such models.

carried out by the author of this study are some of the data required by the whole farm model described in the Chapter 6;

. Land use and ecological reserve estimates are some of the information to be incorporated by the LGP model which are available in publications; and

. Soil type and classification.

Chapter 5 Crop Models Data Validation

5.1 Description of the Crop Models

5.1.1 Background

5.1.2 The biological basis

5.1.3 Management strategies

5.1.4 Input and output files

5.2 Performance of the Crop Models

5.3 Adjustments of the Crop Models for the Paracatu Conditions

5.3.1 Crop Models Evaluation for CPAC/EMBRAPA Conditions

5.3.1.1 The CPAC/EMBRAPA experimental data

5.3.1.2 Comparison of input-output transformations

5.3.2 Suitability of the Crop Models

5.3.3 Crop Models Use for Paracatu Conditions

5.3.3.1 Weather generation

5.3.3.2 Estimation of Crop Yield distributions for each soil type

5.3.3.3 Statistical analysis of the crop yield distributions

5.3.4 Application of the Crop Yield Distributions

5 Crop Models Data Validation

The crop yield estimation procedure which is used in this study constitutes an improvement in farm planning that has been suggested by Faber(1986), McGregor(1986), Jones and Kiniry(1986) and Thornton and Dent(1987). Crop simulation models[1] developed by IBSNAT for studying the effects of environment and management on crop growth and yield are applied to generate crop yield distributions for conditions in the district of Paracatu in relation to a sample of climate years for that area. The models were first submitted to some tests and adjustments by using experimental data[2] and information generated in the research centres of EMBRAPA, which have undertaken most of the recent agricultural research for the development of the "Cerrado" region.

This chapter first presents a brief description of the selected IBSNAT crop (wheat, maize, rice and soybean) simulation models. Secondly, some information on their performance in different locations around the world is presented. Thirdly, some adjustments which were possible with the available Brazilian experimental data and information are briefly discussed.

5.1 Description of the Crop Models

The background, the biological basis, the management strategies and the input data requirements of the above mentioned crop models, are described in this section.

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[1]These models are formal mathematical statements of assumptions based on observations of the field performances of crops, or based on an understanding, or knowledge of the physiological mechanism underlying crop growth and production, Charles-Edwards and Vanderlip(1984).
[2]Experimental data generated in field experiments in the research centres of EMBRAPA.

5.1.1 Background

The IBSNAT approach has been developed with the collaboration of many people and institutions around the world, and is co-ordinated by the University of Hawaii and has as the primary aim

> "the integration of new crops, products, and practices into existing farm systems to make them more productive, without disrupting their existing operations.", IBSNAT Project(1985, pg 1).

Given the difficulties in predicting the outcomes associated with alternative technological packages for a specific crop in a particular ecosystem, the research approach adopted by IBSNAT includes, as a crucial tool, the development of comprehensive crop simulation models which present the possibility of applications[3] in developing countries for making responsible agricultural production choices.

In many developing countries such as Brazil, a difficult agrotechnology transfer issue relates to the extrapolation of research findings from a particular experimental station that covers a large area to other sites, soils, seasons, cultivar and crop management combinations. Hence, the participation of collaborators from developing countries and from crop-oriented international research centers in crop modelling, has been fundamental for the development of this new approach to agrotechnology transfer. It allows the integration of discipline-oriented research with interdisciplinary,

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[3]The prediction of the performance of a particular cultivar sown at any time on any soil in any climate is a goal which may never be completely met because of the complexity in a biophysical system.

> "However, even partially meeting the goal will provide considerable improvement in our ability to transfer agrotechnology information", Ritchie(1986).

systems-based research[4] which allow users to simulate crop outcomes so that the risk of failure can be minimized.

The IBSNAT approach recognizes that crop yield results from the interaction between individual site characteristics and management practices, where optimum conditions must exist with respect to at least five variables:

> "(i) balanced supply of plant nutrients,
> (ii) solar energy,
> (iii) rooting zone with adequate amounts of water and oxygen,
> (iv) crop varieties with the genetic potential to make effective use of environmental and management inputs, and
> (v) crop protection from insects, diseases, animals, weeds, pesticides and other hazards," IBSNAT Project(1987, pg 8).

Consequently, the IBSNAT crop simulation models were designed in a holistic manner through

> " a system-based research strategy which brings together existing knowledge of the farming systems, identifies major components and processes and their interactions, and seeks to identify the bottle-necks to improved performance," IBSNAT Project(1987, pg 10).

5.1.2 The biological basis

The IBSNAT crop simulation models included in this study are the CERES models (wheat, maize and rice versions) and the SOYGRO model (soybean version). All these crop models are based on interconnected physiological and physical relationships that require environmental inputs

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[4]The central concept of systems-based research is that the whole system must be understood in order to evaluate changes to any single component, Spedding(1988).

such as radiation, temperature and rainfall. They are dynamically solved on a daily basis through the life of the crop in order to calculate crop development, growth and final yield. Each model quantitatively predicts both the rate and extent of crop dry matter production and describes the phenology and the morphology of the specific crop.

All the CERES model versions briefly presented here include the description of various processes related to the dynamics of nitrogen in the soil and in the plant as described in Figure A4.1 of the Appendix 4 by Godwin and Vlek(1984). The various interrelationships and feedbacks among evapotranspiration, soil water balance, crop development as influenced by temperature, photoperiod, vegetative growth, root growth, grain growth, and various processes related to the dynamics of nitrogen in the soil and in the plant, are incorporated into the CERES model.

The final yield calculation in any one of the CERES model versions involves primary processes such as:

" i. phasic development and duration of growth stages as related to genetics, weather, and other environmental factors;

ii. apical development as related to morphogenesis of vegetative and reproductive structures;

iii. growth of leaves and stems and senescence of leaves;

iv. biomass accumulation and partioning;

v. effect of temperature and soil water deficit on growth and development; and

vi. effect of nitrogen stress on growth and development, Richardson(1985, pg 1603).

The CERES models, as do the other IBSNAT models, present greater detail (on a daily basis) than the crop modelling methodology (on a weekly basis) discussed by FAO(1986).

SOYGRO V5.41 is another IBSNAT crop model. It is a process-oriented soybean crop growth model developed at the University of Florida by an interdisciplinary research team. Standard input and output formats for climate and soil, and a general soil water balance routine, are included in an attempt to make all the IBSNAT crop models more useful with minimal incompatibilities.

In the IBSNAT crop models development process, a great effort was made to integrate them into the IBSNAT Decision Support system for Agrotechnology transfer (DSSAT). The DSSAT is a piece of computer software that involves data bases, crop models and application programs; it allows different users[5] the opportunity to study alternative crop management strategies.

5.1.3 Management strategies

The CERES and SOYGRO V5.41 models predict information relating to dry matter growth, leaf area index (LAI), crop development, and final yield which depends on daily weather data, cultivar, soil types and management decisions involving planting date, row and plant spacing, nitrogen applications, and irrigation and drainage options. Moreover, simulated experiments with any IBSNAT crop model can be compared in tabular and graphical forms with measured data as illustrated in the following section. Hence, such crop models can be of great assistance in studying crop management strategies.

In terms of water management for crop irrigation, the IBSNAT simulation models can determine the crop water requirements in any season, considering different soils, different varieties, etc. This is an example of

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[5]Users such as agricultural researchers, planners, extension agents, and farm business managers.

application of these models at the farm and research levels. Crop management strategies can be analysed by a team of researchers at a research station aiming to define research priorities, or by rural and agricultural development policy makers.

Given that model predictions depend on the quality of the input data, any crop management strategy must be studied after a final definition of all the model input data.

5.1.4 Input and output files

Given that the IBSNAT project is concerned with a range of crop models (wheat, maize, rice, sorghum, millet, barley, soybean, Phaseolus beans, peanuts, potatoes, cassava and aroids), standardized inputs and outputs have been made. The input standardization enables all crop models to use the same site data to simulate growth and yield responses of each crop for a particular site, and standardized model outputs help all crop model users interpret results from different models and facilitates analysis and graphical presentation, IBSNAT Project(1986).

The input and output files for the IBSNAT crop models are organized into four types as shown in Table 5.1. Field base experimental data files and weather data files are identified in the directory files (EXP.DIR) and (WHT.DIR) respectively. Plant genetics, weather, soil, and crop management information for all treatments of an experiment are entered in the input files (FILE1, FILE2, ... ,FILE0). The plant genetic information includes coefficients related to photoperiod sensitivity, duration of grain filling, conversion of mass to grain number, grain filling rates, stem size and others. The weather information required are daily values of precipitation, maximum temperature, minimum temperature, and solar

Table 5.1 Description of Standard Input and Output Files for the IBSNAT Crop Models

File Variable Names		Description
Directory Files		
EXP.DIR		Directory of files for each experiment.
WTH.DIR		Directory of available weather data.
input files		
FILE1		Daily weather data.
FILE2		Soil profile proprieties.
FILE3		Unused at present time.
FILE4		Soil nitrogen dynamics proprieties.
FILE5		Soil profile initial conditions.
FILE6		Irrigation management data.
FILE7		Nitrogen fertilizer management data.
FILE8		Crop management data.
FILE9	(by crop)	Genetic coefficients.
FILE0	(by crop)	crop-specific coefficients.
Validation files with measured data		
FILEA	(by crop)	Measured summary data.
FILEB	(by crop)	Measured seasonal data for graphics.
Output Files		
OUT1	(by crop)	Output record of crop model inputs. Simulated biomass and water balance components at selected phenological stages. Harvest summary (simulated and observed).
OUT2	(by crop)	Simulated crop variables vs time.
OUT3		Weather variables and simulated soil water balance vs time.
OUT4		Simulated soil nitrogen variables vs time.

Source: IBSNAT Project(1986, pg 6) Decision Support system for Agrotechnology Transfer (DSSAT).

radiation. The soil information required includes soil water holding capacity by depth[6] and coefficients for rooting preference, runoff, drainage, evaporation, pH and radiation reflection. Management information required includes plant population, planting depth and planting date. A third group of files contains field-measured data which are used for comparison with simulated results for all experimental treatments (FILEA, FILEB). The fourth file type contains output results for all experimental and hypothetical treatments that were simulated during one session (OUT1, OUT2, OUT3, OUT4). Outputs include summary results such as shown in the Figures A4.2 to A4.5 of the Appendix 4. Moreover, sensitivity analysis can easily be performed on various management options. For this, user-friendly interfaces were designed in the DSSAT to allow crop model users to select an experiment and then select any or all treatments from the experiment for simulation. Treatment conditions may be modified interactively and simulated results can be plotted as shown by Godwin et al(1989).

5.2 Performance of the Crop Models

The IBSNAT crop models have been designed with the purpose of universal application. Therefore, they must meet the requirements of being able to simulate plant growth and development at any site where each specific crop can be grown.

A great effort has already been made by the IBSNAT project participants for obtaining valid, portable and reliable crop simulation models. For this, an enormous diversity of data bases was used for testing and comparing every important aspect concerning the features

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[6]Up to fifteen soil layers may be specified by the model user.

of each one of these crop models, Ritchie(1986), Jones et al(1986), Ritchie et al(1987), Jones et al(1988) and Ritchie et al(1989).

However, the application of the IBSNAT crop models for specific conditions requires further evaluation with independent local data sets. The extent of local validation depends on the detail[7] of independent local data, plausible sensitivity analysis and calibration procedures. A local evaluation procedure to which some IBSNAT crop simulation models were submitted, is presented below.

5.3 Adjustments of the Crop Models for the Paracatu Conditions

A satisfactory adjustment of IBSNAT crop simulation models for the Paracatu conditions requires a greater experimental effort by Brazilian research institutions. Even with more extensive data, it will still be necessary to calibrate the models for each site.

The purpose of this section is to present the evaluation procedure to which IBSNAT crop simulation models were submitted, as well as their applications for Paracatu "Planicie" conditions.

5.3.1 Crop Models Evaluation for CPAC/EMBRAPA Conditions

Given the limitations of Brazilian experimental data available to evaluate the IBSNAT crop simulation models selected for this study, it has not been possible to relate performance to real local experiences in an objective manner.

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[7]Local data sets are required according to the input files mentioned above. Good data sets present great detail on the process of plant growth, plant genetics, weather and soil types.

Even so, using limited experimental data provided by CPAC/EMBRAPA - Brasilia, it has been possible to carry out a simplified assessment of the crop (rice, maize, soybean and wheat) model performances. The justification for proceeding with such an effort is the fact that all four crop models have been validated under different conditions elsewhere, IBSNAT(1987). This is not sufficient for a complete study but is deemed to be acceptable for present purposes in providing the approach and methodology.

5.3.1.1 The CPAC/EMBRAPA experimental data

The provision of experimental data by CPAC/EMBRAPA followed the Documentation for IBSNAT Crop Model Input and Output Files, (Version 1.0, IBSNAT Technical Report 5, 1986) even though such data were originally generated for another research purpose by a plant physiologist. Such documentation contains a detailed description of all IBSNAT crop model input data requirements. All the referred field experimental data are organized by each crop simulation model in different input files, except the long (fourteen and a half years) weather data file 1 which is the same for all crop models and contains the daily temperatures (minimum and maximum), solar radiation, rainfall data and the latitude (15.47 S) and longitude (47.55 E) parameters. The CPAC/EMBRAPA meteorological station is located 100 metres from the locale where the experiments were conducted. Such input files are not included in the Appendix 4 because they require the inclusion of the sizable IBSNAT report mentioned above.

It is important to mention the following concerning the CPAC/EMBRAPA experimental data:

i. the genetics coefficients[8] used to define the different genotypes of the experiments were not provided by CPAC/EMBRAPA as is explained in the section 5.3.1.1 below;

ii. the specification of the parameters that refer to the soil profile initial conditions[9] of all experiments were carried out by CPAC/EMBRAPA's researcher as "educated guesses"; and

iii. the parameters for each soil profile were defined with the participation of CPAC/EMBRAPA researchers by using primary data of local soil analyses, general information of a soil survey report (see EMBRAPA, 1983), crop model documentation and local experiences. However, parameters such as bare soil albedo, soil water drainage constant, organic carbon concentration in each soil layer and runoff curve number, were only approximately estimated.

5.3.1.2 Comparison of input-output transformations

One way to validate a model of an existing system is to compare the outputs of the real world system and the model using identical inputs. The crop models mentioned above are in some way input-output transformation devices. Then, comparisons involving actual and model predicted results are fundamental for evaluating the performance of such crop models.

Given the field data limitations mentioned above and the absence of trial results of each crop genotype used in the experiments, in this study, the tests of such crop

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(8) Coefficients such as: growing degree days base 8^0C (GDD_8) from seedling emergence to the end of juvenile phase, photoperiod sensitivity coefficient, and potential kernel growth rate for the CERES model versions.

(9) For each defined soil layer, parameters such as the soil water content in cm^3/cm^3, soil ammonium in mg elemental N/kg soil and soil nitrate in mg elemental N/kg soil, are required.

models are restricted to comparison of input-output transformations. In a subjective way, genetic coefficients and soil parameters were adjusted in an effort to match observed and simulated output variables (such as yield, final biomass and maturity date) as shown at the Figures A4.2 to A4.5 of the Appendix 4.

Once such adjustments are completed, the crop models were used to generate crop yield distributions for the CPAC/EMBRAPA station conditions. Using thirteen years of historical weather data and the same crop management conditions followed in the field experiments referred to above, crop yield cumulative probability distributions were obtained as shown in the Figure A4.6 of the Appendix 4.

5.3.2 Suitability of the Crop Models

The crop model predicted results alongside measured results shown in the lower sections of Figures A4.2 to A4.6 of the Appendix 4 demonstrate the limitation of Brazilian experimental data and that more complete field experimentation is required. The observed and simulated output variables did not match very well. With complete data as required by the crop models and some trial results, it would be interesting to compare trial yield results, statistically[10], with the predicted yield distribution curves, (see Figure A4.6 and Figures A4.8 of the Appendix 4). However, this was not possible.

Consequently, until more thorough model validation can be completed for Brazilian conditions, it is suggested that such crop models only be used in a research environment but not for predictive purposes in a real planning

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[10] Kolmogorov-Smirnov tests could be used to compare the two (actual and predicted) crop yield distributions.

process yet[11]. Nevertheless it was felt appropriate for the purposes of this study to use the crop models in order to complete the methodological approach.

5.3.3 Crop Models Use for Paracatu Conditions

The IBSNAT crop models were then used to define some crop yield distributions for specific Paracatu conditions as briefly discussed below.

5.3.3.1 Weather generation

A computer simulation model called WGEN (Weather Generator) which has been developed for the U.S. Department of Agriculture by Richardson and Wright(1984), was applied[12] in this study. WGEN is in the simplest sense an input-output transformation device. Designed to preserve the dependence of time, the correlation between variables, and the seasonal characteristics in actual weather data, the WGEN model provides daily values for precipitation, maximum temperature, minimum temperature, and solar radiation for a n-year period at a given location, Richardson(1985).

Using eleven years of Paracatu district's daily weather data[13], WGEN generated daily values for the variable mentioned above, for a seventy-year period. Ideally, such data should be for more than a 11 year period to produce a better representation of the local situation.

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[11] A great effort to calibrate the IBSNAT crop models for Brazilian conditions is necessary. This requires complete field experimental data, trial results (from the station and farms) and appropriate adjustments of such models as mentioned in Chapter 5 (section 5.3).

[12] The collaboration of Dr P. Thornton (IBSNAT Project scientist) was fundamental because he has adapted WGEN model for tropical conditions.

[13] The "Instituto Nacional de Meteorologia do Ministerio da Agricultura do Brasil" provided daily weather data of the Paracatu District station for the period 1968 to 1978.

Thus, Figure A4.7 of the Appendix 4 shows a graph with historical and simulated monthly mean rainfall and another graph with the corresponding standard deviations.

5.3.3.2 Estimation of Crop Yield distributions for each soil type

Using 31 years of weather data[14] generated by WGEN as the input file 1 for the IBSNAT crop simulation models and the other adjusted (with CPAC/EMBRAPA experimental data) crop model input files, it was possible to estimate the crop yield distributions of selected crops (rice, wheat, maize and soybean) for Paracatu "Planicie" conditions. Some planting date variations were necessary to represent crop activities at farm level. Table A4.1 and Figure A4.8 of the Appendix 4 show the crop yield distributions (with the respective mean and standard deviation) estimated for each soil type of the Paracatu "Planicie".

5.3.3.3 Statistical analysis of the crop yield distributions

Two statistical tests were conducted to analyse the crop yield distributions mentioned above. These statistical tests were necessary to define how to incorporate the characteristics of the distributions into the CECROPF farm model. First, the Lilliefors test[15] for normality was conducted to compare each crop yield distribution with a normal distribution (see Table A4.2 of the Appendix 4). Secondly, a correlation matrix between different crop yields in different soil types in the same years was established as shown the Table A4.3 of the Appendix 4.

The Lilliefors test results described in Table A4.2 of the Appendix 4 show that all but two of the Paracatu

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[14] It is assumed that 31 years of weather data is acceptable from the statistical point of view.
[15] Lilliefors test is one of the goodness-of-fit tests for families of distributions presented by Canover(1980).

"Planicie" crop yield distributions (estimated) are not significantly different at the 5 percent level from the normal distribution fitted to the same data. For the sake of simplicity it was assumed that all distributions could be treated as normal.

The correlation matrix described in the Table A4.3 of the Appendix 4 shows that some of the correlation coefficients between different yield distributions of different crops, are highly significant. Thus, it was decided to incorporate the crop activity outcomes (yields) of the CECROPF model in such a manner as to preserve these correlations. This is explained below.

5.3.4 Application of the Crop Yield Distributions

Using spreadsheet SuperCalc 4 software the Paracatu "Planicie" crop yield distributions were randomly sampled ten times for each crop alternative incorporated into the CECROPF model MOTAD version This sampling was carried out on the unordered yield distributions to preserve the correlations observed between crops within years (see Table A4.3 of the Appendix 4).

On the other hand, the CECROPF model standard version incorporated no more than the mean of each of the different crop yield distribution mentioned above.

Chapter 6 Design, Data Structure and Operation of the Whole Farm Model

6. Farm Level Model Design and its Data Structure

6.1 Introduction

Chapter 5 described the characteristics and the strength of the IBSNAT crop simulation models in farm planning. Appendix 2 briefly describes the effort of price series modelling which has been developed under the assumption that farmers will be better able to protect themselves against financial losses resulting from adverse farm product price movements by using predictions with improved price forecasting techniques. Following these steps, the modelling framework described in Figure 4.1 shows that the information generated with the crop simulation models and price series forecasting models are incorporated into the whole "Cerrado" crop farm (CECROPF) model which is a multi-period mixed integer linear programming model with MOTAD formulation.

The CECROPF model matrix is designed on a monthly (for the first four years) and yearly (for the remaining six and half years) basis as a discounted cash flow. The objectives established for this study were considered as crucial elements in the discussion of the potential for commercial crop farming in a natural "Cerrado" area. This farm development is looked at from the point of view of a decision-maker responsible for agricultural credit policies. A large part of the data incorporated in the CECROPF model is a synthesis of information supplied by the public and private Brazilian advisory services and the experience of the author. The CECROPF model involves a 10 1/2 year equilibrium model structure. This was considered the minimum pay-back period required for the farm development investments. The non-standard time horizon used for the analysis was necessary to synchronise production and financial years. It has been developed to analyse different crop farm systems by selecting different farm enterprises, farm resources, agricultural credit policies and other management strategies which maximize a long-term discounted cash flow.

Thus, the CECROPF model represents the main technical and financial management features of a new crop farming system. The range of farm systems generated by CECROPF under alternative assumptions about farm size and credit provision strategies are then suitable for inclusion in a regional level goal programming model, which is described in the next chapter. The use of goal programming allows selection of a 'best' farm system while giving consideration to the objectives of an integrated rural development program.

This chapter describes the main features of the CECROPF model. However, the various sub-matrices of the first year CECROPF model are described with comments in Appendix 3.

6.2 An Overview of the "Cerrado" Commercial Crop Farm System

The CECROPF model, as described in this chapter, is based on a new "Cerrado" farming system which is characterized by modern[(1)] technological packages already tested with success in agronomic terms, Momma(1985). It is oriented to the "Planicie" area of the Paracatu District environment (which is located at latitude 17, longitude 46, and 677 metres altitude) in the state of Minas Gerais, Brazil (see Figure 3.2). The climate of the area is sub-tropical with most rain falling from October to April followed by a dry season from May to September. Most of the crops are sown in October to November and

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[(1)]Technological packages which include, basically, improved seeds, adequate fertilization and mechanical operations.

harvested in March to May. Lime, phosphate, nitrogen and trace element fertilization have allowed the development of the predominantly infertile, acid soils.

Crop farm development projects implanted into the "Cerrado" region (by POLOCENTRO and PRODECER) have followed a standard crop farm size of around 400 hectares. Most (up to 80 percent) farm land has been cleared and is already used for cropping. Farm operations of such farms are highly mechanized and most farms are family owned and managed. However, labour is relatively cheap in Brazil and thus is not a problem in any task such as crop seeding, maintenance and harvesting.

The CECROPF model includes four crop enterprises: rice, maize and soybean in the rainy season and irrigated wheat in the dry season. Other crop enterprises could be incorporated but those mentioned above are the ones most adopted by farmers who intensively farm the poor "Cerrado" soils.

6.3 Design of the CECROPF Model

The CECROPF model is developed according to the established problem and objectives of this study, as well as the 'skeleton' model concept which

> "relies on the fact that (certain) parameters form the basic logic of given real farming system and that this logic is unchangeable from farm to farm," Dent and Blackie(1979, pg 163).

Moreover, the whole farm system conceptual model described in the Figure 6.1 is fundamental in defining the main components.

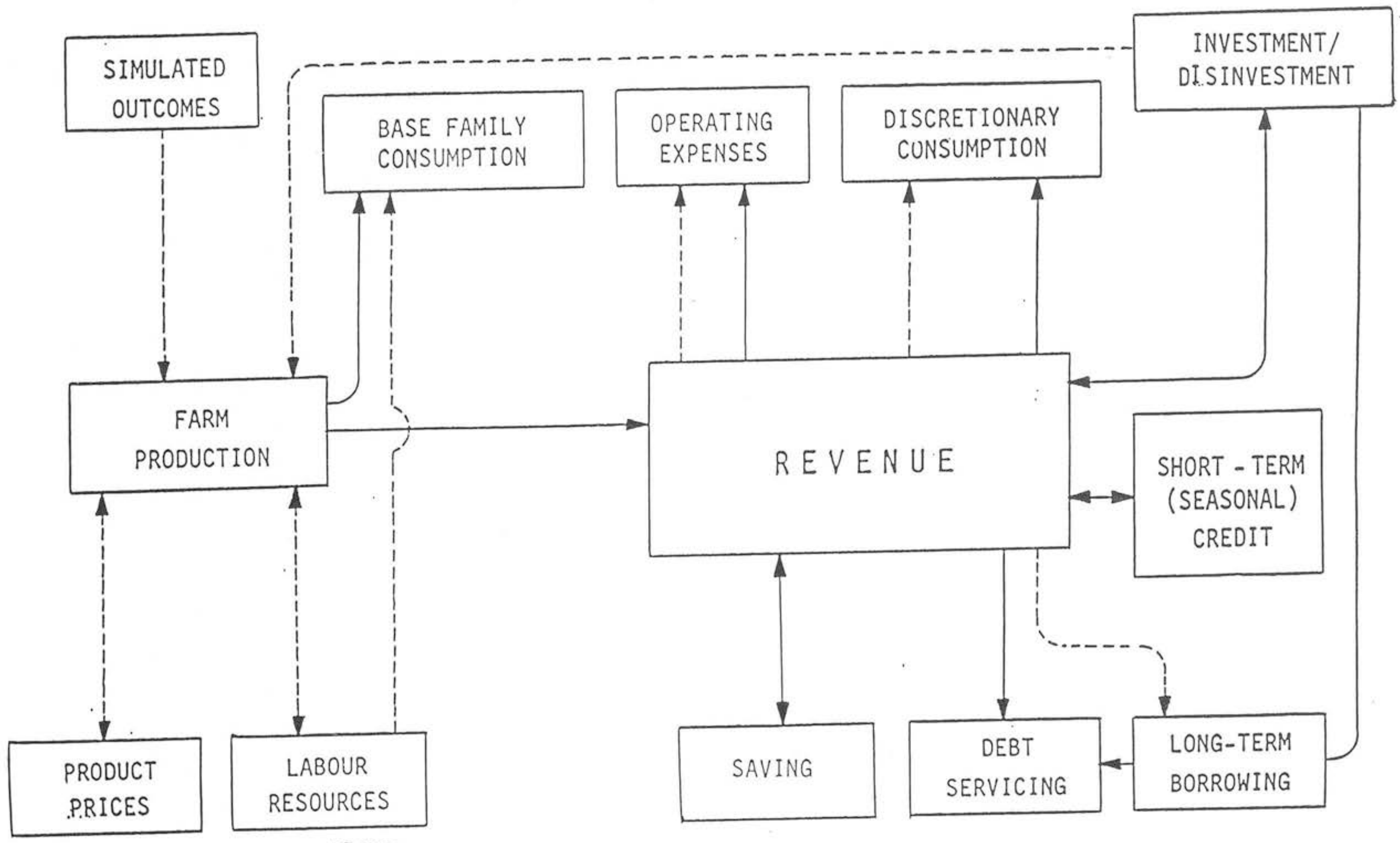

Figure 6.1. Conceptual Whole Farm System Model

____ flow of funds ---- flow of Influence

Source: Thornton and Dent(1987) - IBSNAT Crop Models in a Socio-Economic Whole Farm Farmwork Agrotechnology Transfer 2, Honululu, Hawaii.

The development of the CECROPF model has involved mathematical representation of wide ranging and complex issues. The details of the CECROPF model have been carefully considered in the light of the problem under discussion. The structure is established on a monthly basis for the first four years (assuming that this is a reasonable period for the household's settlement) and on a yearly basis for the remaining six and half years (assuming that the farm system, after the first four years, will be reasonably established and thus the level of aggregation on a yearly basis would be satisfactory from the point of view of a project analyst).

The incorporation of crop yields and grain prices in the CECROPF model is not so simple. Fluctuations in regional grain prices are handled with respect to their trends as explained in Appendix 2. The crop farm biological processes are represented by IBSNAT crop simulation models (discussed in Chapter 5) which are used to establish the crop yield distributions. (Appendix 4). The crop yield averages are directly incorporated in the CECROPF model standard version. However, the CECROPF model risk version involving the MOTAD formulation also requires the crop yield distributions to be accessed randomly[2] to represent the crop enterprise agronomic results.

6.3.1 Matrix writing

The CECROPF model matrix writing process involved three main steps. A first step where all the first year constraint blocks related to a new crop farm business are described, (Figure 6.2). The second step is related to the details of the whole CECROPF model matrix which is illustrated in Appendix 3. The third main step is the

[2]The generation of ten random crop yield values for each crop activity is appropriate, Thornton(1989 pers. com.) (see Appendix 4).

Figure 6.2 First Year Framework of the CECROPF Model Standard Version

ACTIVITIES		Soil preparation	Crop activities	Other activities	Investments in assets	Irrigation systems	Machinery "binary"	Own tractor hours	Labour	Employed workers	Seasonal workers	Hired machinery	Capital transfers	Commercial credit	Agricultural credit	Machinery var. costs	Direct input costs
CONSTRAINTS																	
Soil classes Y=01 (supply)	=>	D															
Irrigatable soils (supply)	=>	D															
Irrigation permission	0 =>	S				D											
Water supply	0 =>		D			S											
Soil preparation inv.	0 =>	D															
Soil use ties	0 =>	S	D			T											
Investments in assets	0 =>					D	D										
Family labour (supply)	=>		D	D													
Employed tractor drivers	0 =>						S			D							
Employed driver hours	0 =>		D	D						S		S					
Seasonal labour	0 =>		D								S						
Tractor number	1 =>						D										
Available tractor hours	0 =>						S	D									
Tractor requeriments	0 =>		D					S				S					
Harvester requeriments	0 =>		D									S					
Maintenance costs	1 =																
Machine variable costs	0 =>							D				D				S	
Costs of direct inputs	0 =>		D								D						S
Asset's evaluation	0 =>	S				S	S										
Working capital (supply)	=>						*D			D			T	S		D	D
Overdraft (short term)	0 =>		S														
Long term investments	0 =>																
Market capital	1000 =>													D			
Production for sale	0 =>		S														
Income ties	0 =>																
Pos-tax income	0 =			S										D			
Income allocation	0 =																
Used soil ties	0 =>	D															
Rotation	0 =>		S														
Irrigation systems	0 =>					S											
Tractor aquisition	0 =>						S										
Overdraft bills	0 =>																
Mortgage	0 =>																
Asset value	0 =>																
Production carry-over	0 =>																
Farm business cash	0 =>																
Farm business deficit	0 =>																

ACTIVITIES	Long term inv.	Transference of ag. cr.	Overdraft credit	Maintenance costs	Family consumption	Discretionary cons.	Overhead costs	Sales	Production transfers	Income transfers	Invested capital	Assets after deprec.	Pos'tax income	Cash surplus	Deficit
CONSTRAINTS															
Soil classes Y=01 (supply)															
Irrigatable soils (supply)															
Irrigation permission															
Water supply															
Soil preparation inv.		S													
Soil use ties															
Investments in assets		S													
Family labour (supply)															
Employed tractor drivers															
Employed driver hours															
Seasonal labour															
Tractor number															
Available tractor hours															
Tractor requeriments															
Harvester requeriments															
Maintenance costs					1	1	1							-.3	
Machine variable costs															
Costs of direct inputs															
Asset's evaluation												1			
Working capital (supply)			S		D		D			S	1				
Overdraft (short term)			D												
Long term investments	S	D													
Market capital															
Production for sale								D	D						
Income ties								S		D					
Pos-tax income											-1.01		1.		-1
Income allocation													-1.	1.	
Used soil ties															
Rotation															
Irrigation systems															
Tractor aquisition															
Overdraft bills			D												
Mortgage	D														
Asset value												-.9			
Production carry-over									S						
Farm business cash														-.7	
Farm business deficit															1.02

ACTIVITIES (TRANSFERS)	Soil information	Rotation	Irrigation systems	Tractor aquisition	Overdraft bills	Mortgage	Asset's transfer	Production carry'over	Farm business cash	Farm business deficit
Used soil ties	S									
Rotation		D								
Irrigation systems			D							
Tractor aquisition				D						
Overdraft bills					S					
Mortgage						S				
Asset value							1			
Production carry-over								D		
Farm business cash									D	
Farm business deficit										S

(Second Year...)

(...continue in the next page...

CONSTRAINTS	ACTIVITIES: Soil preparation	Crop activities	Other activities	Investments in assets	Irrigation systems	Machinery "binary"	Own tractor hours	Labour	Employed workers	Seasonal workers	Hired machinery	Capital transfers	Commercial credit	Agricultural credit	Machinery var. costs	Direct input costs	Long term inv.	Transference of ag. cr.	Overdraft credit	Maintenance costs	Family consumption	Discretionary cons.	Overhead costs	Sales	Production transfers	Income transfers	Invested capital	Assets after deprec.	Pos. tax income	Cash surplus	Deficit	TRANSFERS: Soil information	Rotation	Irrigation systems	Tractor aquisition	Overdraft bills	Mortgage	Asset's transfer	Production carry'over	Farm business cash	Farm business deficit	(Second Year...)
Soil classes Y=02 (supply) =>																																D										
Irrigatable soils (supply) =>																																D										
Irrigation permission 0 =>																																		D								
Water supply 0 =>																																		S								
Rotation possibilities 0 =>																																	S									
Family labour (supply) =>																																							D			
Employed tractor driver 0 =>																																			S							
Employed driver hours 0 =>																																							D			
Seasonal labour 0 =>																																							D			
Available tractor hours 0 =>																																			S							
Tractor requirements 0 =>																																							D			
Harvester requirements 0 =>																																							D			
Costs of direct inputs 0 =>																																							D			
Asset's evaluation 0 =>																																						-1				
Mortgage 0 =>																																					D					
Working capital 0 =>																																				D				S	D	
Production for sale 0 =>																																							S			

Abreviations: D demanded quantity, S supplied quantity, T transference,
*D demanded quantity of own capital to adquire machinary (years 1,2,3,...,10)

incorporation of the MOTAD formulation in the CECROPF model standard version.

The CECROPF model standard version involves 1,686 rows, 29 integer variables and 2,060 non-integer variables. The CECROPF model MOTAD version involves 2244 rows, 29 integer variables and 3281 non-integer variables.

6.4 CECROPF Model Data Structure

All the CECROPF model financial data were defined in terms of National Treasury Bills (OTN). Although abolished on 16 January 1989, and subsequently replaced by the National Treasury Bonus (BTN), OTNs provide a useful index that are still widely recognised and extend back to the start of the period under study.

The most relevant aspects of the CECROPF model data structure are described below.

6.4.1 Initial farm resources

6.4.1.1 Land

Under the natural vegetation (74 percent of the 267,100 hectares) of the Paracatu "Planicie" area, three different soil types are identified, (Franz(1988), pers. com.).:

- .Latossolo vermelho amarelo - LVA represents about 20 percent of the area;
- .Latossolo vermelho escuro - LVE represents about 60 percent of the area; and
- .Latossolo hidromorfo - LHi represents the remaining 20 percent of the area.

Given the availability of water for irrigation in the Paracatu "Planicie" area, the CECROPF model has included irrigated and non-irrigated crop activities. Such crop activities are described below.

Farm area is a critical factor in the outcome of any development program and has been explicitly included in the analysis by integrating the CECROPF model results in a regional context as mentioned above.

6.4.1.2 Family labour

The initial farm labour resource was assumed to be limited to the owner operator. The farmer's available time is assumed to be up to 200 hours per month. The farmer allocates part of his time to sowing and harvesting operations. However, the farmer has plenty of time left for management activities.

6.4.1.3 Finance

In the first instance it is assumed that farmers are not in debt and that they own a minimum of 1,000 OTN with which to start the new crop farm..

6.4.2 Cropping

Up to 26 crop activities are included in each year of the CECROPF model. These cropping activities are defined by season, soil type and rotation: for example, irrigated wheat planted in the dry season on LVE soil type following soybean is one defined crop activity. The analysis involved developing land that was initially growing natural vegetation and introducing commercial cropping rotations both with and without irrigation. Specifically, three non-irrigatable soil types were planted to rice, maize or soybean. The viability of irrigation was analysed for wheat (dry season) and soybean (rainy season) on two soil sub-areas. Rotational constraints were imposed for husbandry reasons on the sequence of crops that could be grown. Consequently, after the first year of farm development the above crop-soil combinations were repeated for both land that was initially growing natural vegetation and soil areas in a rotational process (soybean-cereal and vice-versa), providing 26 possible combinations.

Crop technical coefficients were estimated with the participation of EMATER-DF advisers. The maize crop requires more seasonal labour because of some specific operations involving nitrogen application and weed control.

Machinery for the mechanical operations required by the crop activities can be hired from a cooperative or contractor. This involves trade-offs between hired and farmer-owned machines.

During the sowing and harvesting operations the participation of family labour is considered within the model because they are the crucial cropping operations.

Production seasons, soil preparation and land acquisition investments, costs of direct inputs, crop yields and rotations are other relevant aspects included in the crop activities discussed below.

6.4.2.1 Production seasons

A farm production year has been defined as the period between the first of May to the thirtieth of April. Two different production seasons have been included in this period: a dry season from the first of May until the end of September and a rainy season from the first of October until the end of April.

It is assumed that the first ploughing operation of the rainy season crops is carried out in September. The rainy season maize crop finishes in the first month (May) of the following year. However, the end of the agricultural year is 30 April when the rice and soybean harvests are completed.

Irrigated wheat crops start at the beginning of the agricultural year in May and finish at the end of September. An advantage of such irrigated crops is the use of available resources during the dry season.

6.4.2.2 Soil preparation and land acquisition investments

The soil preparation activities have included the following investment costs:

Quant.	Unit	OTN/hectare[3]
6.	tons of lime[4] + transport	19.31
1.2	tons of natural phosphorus + transport	10.16
600.	kg of P2O5 + transport	10.97
20.	kg of Zn sulphate	1.07
100.	kg of K	2.19
15.	kg of micro-nutrients	0.71
		44.41

It is assumed that the chemical properties of the three "Cerrado" soil types do not present significant differences. However, the operational costs involved in clearing, soil conservation (terraces), lime and natural phosphorus incorporation depend on the "Cerrado"

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(3)The values were estimated in March 1988.
(4)Given the low pH of the "Cerrado" soils, other lime applications are necessary in the subsequent years. Such lime applications are considered in the overhead costs.

vegetation. The vegetation varies with the soil type. So, the EMATER -DF has estimated such operational costs as:

Soil type	OTN/hectare[3]
LHi soil	33.53
LVA soil	67.49
LVE soil	58.14

The irrigatable soils can be used at least twice a year.

Farm land has been divided into three soil type areas (in hectares) as mentioned above. These soil areas are subdivided into irrigated, non-irrigated, first year cultivation and rotation sequences involving cereals and soybean crops. Any farm system is limited to 80 percent of the land area because 20 percent is, by law, an ecological reserve.

Soil preparation constraints can also include the land acquisition cost depending on the matrix preparation discussed in Section 6.5.1 below. Land acquisition cost has been estimated at 22.76 OTN per hectare. Such an estimate relies upon PRODECER investment projects designed in 1988.

6.4.2.3 Costs of direct inputs

The costs of direct inputs estimated for each alternative crop enterprise are as follows:

Crop	Quant.	Unit	Input		OTN/hectare[3]
rice					
	40.	kg	seed	Cr$ 1400.	
	200.	kg	fertiliser 4-30-16 + Zn Cr$ 5294.		
	0.12	litre	insecticide	Cr$ 108.	
	2.	kg	fungicide	Cr$ 1600.	
	0.28	kg	fungicide	Cr$ 140.	
	0.5	kg	insecticide	Cr$ 32.	

					10.45
	27.	bags[5]	packing	Cr$ 1350.	1.65
maize					
	20.	kg	seed	Cr$ 1200.	
	200.	kg	cloreto potassium	Cr$ 3400.	
	300.	kg	fertiliser 4-30-16 + Zn	Cr$ 7940.	
	5.	litres	herbicide	Cr$ 7000.	
					23.82
	80.	bags	packing	Cr$ 4000.	4.88
soya					
	80.	kg	seed	Cr$ 2800.	
	300.	kg	fertiliser 4-30-16 + Zn	Cr$ 7940.	
	1.	kg	insecticide	Cr$ 900.	
	0.2	kg	fungicide	Cr$ 100.	
			herbicide	Cr$ 1400.	
	1.	kg	insecticide	Cr$ 64.	
					16.09
			electric power for supplementary irrigation		5.50[6]
	40.	bags	packing	Cr$ 2000.	2.44
wheat					
	180.	kg	seed		3.39
	300.	kg	fertiliser 4-30-16 + Zn		9.60
	10.	kg	fertiliser Borax		0.37
	300.	kg	ammonia sulphate		3.65
	1.5	litres	herbicide 2_4D		.96
	2.	litres	herbicide Herbadox 500		1.75
	0.5	litre	fungicide Tilt		2.35
	0.48	kg	fungicide Bayton		1.99
	0.30	litre	insecticide Azodrin		0.22
	0.90	litre	insecticide dimeotato CE 400		0.65
					24.93
			electric power		11.00[7]

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[5] A bag is a 60. kg unit for packing grain and cereals.
[6] Supplementary irrigation costs: 0.5 OTN in November, 2.5 OTN in January and 2.5 OTN in February.
[7] Irrigation costs: 2 OTN in May, 7 OTN in July and 2 OTN in August.

42.	bags packing	2.57

6.4.2.4 Crop yields

Crop yield coefficients for the alternative crop enterprises are estimated by using the crop yield distributions described in Appendix 4. Such data are unavailable from the region.

6.4.2.5 Rotations

Basically, the rotations included in the CECROPF model establish that a cereal crop is followed by a soybean crop and vice-versa.

6.4.3 Non-commercial production activities

Given that an employed tractor driver can offer up to 208 labour hours per month, non-commercial production activities are included to represent an alternative use for such a resource. It is assumed that non-commercial production activities are required for household development.

6.4.4 Machinery use costs

It is assumed that a tractor or a harvester can supply 200 service hours per month. Owned and hired machinery use options can be chosen by the farmer.

6.4.4.1 Owned machinery

The direct costs of using own machinery for farming purposes have been estimated by the "Comissao de Financiamento da Producao" (CFP), and are set-out below a medium sized tractor and a harvester.

Item	medium size tractor		harvester	
	June/87	OTN/hour	June/87	OTN/hour
occasional repairs	Cr$ 66.20		Cr$ 265.00	
periodic maintenance	Cr$ 44.10		Cr$ 176.70	
oil	Cr$ 140.02		Cr$ 150.74	
filters	Cr$ 3.42	0.88	Cr$ 3.42	1.99

In addition a farmer owning machinery has further costs related to capital expenditure which include interest charges and replacement costs.

6.4.4.2 Hired machinery

It is assumed that hired machinery services can be provided by a farmers' cooperative or by someone else.

The hired tractor cost has been estimated at 1.27 OTN/hour.

The hired harvester cost has been estimated at 3.83 OTN/hour.

6.4.5 Hired labour costs

Labour can be contracted on a monthly or daily basis at a relatively low cost. The contracted worker on a monthly basis takes an important responsibility, that is, the mechanical activities. The daily basis worker is involved in cultivation-associated activities.

6.4.5.1 Employed worker

One employed worker offers 208 hours of labour per month, except in December and February when 108 labour-hours are taken for holiday. The cost of one employed worker has been estimated at 15.21 OTN per month plus a 13th monthly payment made annually at the end of April when an agricultural year is completed.

6.4.5.2 Seasonal worker

It is assumed that one seasonal worker day is equal to 8 hours of labour and its cost is 0.36 OTN/day.

6.4.6 Maintenance costs

Maintenance costs in the CECROPF model refer to the farmer's family basic consumption as well the discretionary consumption.

6.4.6.1 Family consumption

Family consumption is included in the CECROPF model as a fixed cost. It has been estimated by EMATER-DF that a reasonable level of farmer family consumption would be 30.42 OTN/month which corresponds to about US$ 240.00/month.

6.4.6.2 Family's discretionary consumption

Discretionary consumption occurs with a cash surplus at the end of any agricultural year.

It is assumed that 30 percent of the farm cash at the end of the year is used in non-commercial activities such as household improvements, for example a new car or other expenditure. Moreover, it is assumed that part of this so-called discretionary consumption (80 percent of this 30 percent) is directed towards purchases that have a resale value, should this be required to release cash out at some time in the future..

6.4.6.3 Overhead fixed costs

Overhead fixed costs refer to all the other maintenance costs of the farm. The overhead fixed costs for each month have been estimated by taking educated guesses of experience on a commercial crop farm in the Federal District - Brazil, Veloso(1984). Different farm classes[8] involve different overhead fixed costs.

6.4.7 Key financial variables and parameters

Given that the CECROPF model involves a ten and half year cash flow, there are many financial variables and parameters incorporated within it, some of which are described below.

6.4.7.1 Grain and cereal prices

Rice, maize, wheat and soybean are sold on a monthly price basis in 60 kilogram units. These farm gate prices[9] are estimated by using historical time series collected by "Fundacao Getulio Vargas - FGV" - Rio de Janeiro - Brazil. Details of the procedures developed for farm product price forecasting are presented in Appendix 3.

6.4.7.2 Limits and interest rates of short term agricultural credits

Given the requirements of working capital by the farm activities, it is assumed that the farmer can use short term overdrafts established according to the ("Valor Basico de Custeio - VBC") Brazilian agricultural credit

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[8]Farm classes such as:
i. small size - less than 200 hectares;
ii. medium size - bigger than 200 hectares and smaller than 400 hectares;
iii. large size - bigger than 400 hectares.

[9]Farm product prices expressed are values of 60 kilogram units after 17.5 of product commercialization tax but before 2.5 percent of FUNRURAL tax.

policy. The VBCs have been established on an OTN/hectare basis. So, the limits of short-term overdrafts for machinery maintenance and other direct input costs defined for each crop in 1987, are incorporated in the CECROPF model.

In terms of interest rates for short-term overdrafts, it has been assumed that they must be established on a monthly basis. Different real interest rates are studied.

Repayments of short-term overdrafts are made at the end of July as has been adopted in Brazil.

6.4.7.3 Interest rates, debt service and quantity of long term agricultural credits

Three different investment credit plans are included in the CECROPF model. They consider different interest rates and payment shares that can take up to a ten year period. For instance, by using any investment credit in the fourth year, it is established that the farmer would have six years to repay it.

Such long-term investment credit plans are required for acquisition of land, a tractor, irrigation systems and soil fertility improvements. The quantity of credit depends on the farm business size.

Investments in machinery are considered by including a medium (80HP) tractor with equipment for 7100 OTN, a single medium (80HP) tractor for 3140 OTN, a harvester (100HP) for 5670 OTN and two alternative conventional irrigation systems at a price of 220 OTN/hectare. It is assumed that the farmer has 10 percent of the required capital available for financed machinery investments. Moreover, investments in a second tractor or a harvester require 100 percent of farmer's own capital, since no public funding is available in this instance.

Most of the machinery investment activities in the model involve binary variables.

Any tractor acquisition allows a tractor driver to be contracted. Different irrigation systems supply different quantities of water depending on the soil type.

Payments of long term agricultural credits are made at the end of September. This has been adopted by most of the Brazilian financial institutions.

6.4.7.4 Taxation, saving and market capital

It is assumed that the available working capital in any month of the year is transferable to the following month at a real interest rate of 1 percent.

The real interest rate for commercial credit is 2 percent per month. The credit limit at any time being 1000 OTN.

The sales of the maize, rice, wheat and soybean products generate the farm income. However, 2.5 percent of such income is retained by the government as tax (FUNRURAL).

6.4.7.5 Discount rate

In neoclassic capital theory the discount rate concept is linked to the marginal efficiency of capital in free market system. In practical terms, a discount rate is generally used in a policy or decision model in order to calculate the present value of a variable by transferring its future value into the present, Braat and Van Lirop(1987). A 10 percent discount rate is used in the present study. The net trading balance in each year is discounted by this annual discount rate and aggregated to give a total NPV for the whole planning period.

6.4.7.6 Assets depreciation

The farm asset value in year t is transferred to the following year t+1 less 10 percent annual depreciation[10]. Investments in land acquisition, in fertiliser for soil fertility correction, and in machinery, form the farm asset account[11].

6.4.8 Transfer activities

6.4.8.1 Production carry-over

The agricultural products can be transferred from one month to the following one.

At the end of a year t, the amount of rice and soybean available can be transferred to the following year t+1 because they are harvested during the last two months (March and April) of the agricultural year. By allowing production carry-over activities, the sales options are extended.

6.4.8.2 Others

(i). Capital transfer

At the end of the agricultural year, the available working capital is transferred to a post tax income account.

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[10]Land is not a depreciable asset but the soil fertility correction investments are.
[11]Other capital purchases are also transferred to the following year t+1 less 10 percent annual depreciation but in a separate account.

Annual cash surplus at the end of year t is transferred to the following year t+1, as well as any cash deficit. However it is assumed that part of the cash surplus can be allocated as discretionary consumption by the farmer as mentioned above.

(ii). Information transfer

Land use information must be updated periodically. So, the soil information activities are used to adjust the available soil areas; and rotation activities are used to represent the soil areas incorporated into the farm's production process.

Information about machinery and irrigation system acquisitions, overdraft bills, mortgage plans, asset values, rice and soybean carry-overs and farm cash is also transferred from year t to the following year t+1.

6.5 Using the CECROPF Model in a Farm Development Conflict Analysis Framework

6.5.1 Matrix modifier

A CECROPF model matrix modifier is required because two different (standard and risk) versions are involved and their MPS format inputs are included in eight files with many comments on the constraints and variables. Moreover, a decision is included about the inclusion of the land acquisition price as a investment to be paid, (see Appendix 5).

6.5.2 Summary of CECROPF model results

The final CECROPF model outcome is the NPV of the farm business in OTN. This procedure defines the farming systems, their resource use and profitabilities. The various systems are shown in detail in Appendix 6 but a summary is provided in Table 7.2.

The main farm level outputs resulting from this CECROPF analysis which forms the basis of the regional GP model are:

- public capital requirements for investments in soil preparation and machinery;
- total area cultivated with each alternative crop;
- total hired labour;
- total discretionary family consumption;
- initial own capital requirement;
- market capital requirement; and
- net farm business revenue.

Optimising the single NPV (financial efficiency) objective of a farm business, CECROPF establishes the resource requirements of a specific farming system. However, in an integrated rural regional development context, trade-offs must be made among diverging objectives (i.e., economic, social and environmental) in order to select the most appropriate farming system(s). In this regard, the GP model described in the next chapter has been included in this study because it offers a suitable methodology to analyse integrated economic-social-environmental planning issues, McGregor(1986) and Braat <u>et al</u>(1987).

Chapter 7 Regional Level Model Data Structure

7. Regional Level Model Data Structure

7.1 Introduction

The CECROPF model (described in Chapter 6) incorporates the major biological, financial and social (family consumption, family and hired labour) aspects at the farm planning level, but it has a single objective; the maximisation of NPV of the farm business. Therefore, its comparative dynamic production structure[1] provides some intermediary outcomes of farmers' production and investment decisions. This information provides the basic data for the regional planning problem which is characterised by the need to solve multiple conflicting goals and objectives. Such a multiple objective decision problem can be modelled using the multicriteria decision making approaches suggested by Cohon(1978), Mendoza et al(1987), McGregor and Dent(1988), and Romero and Rehman(1989). Goal programming has been chosen to represent the expansion of the single farm models into a regional context. Goal programming was chosen for the following reasons; its potential to mimic the decision making process (where goal setting and goal ranking are essential issues); successful applications in a number of previous studies involving the resolution of resource use conflicts; and access to reliable software, Lee(1972) and Bartlett(1976).

This chapter describes the background to the problem, aspects of multiple objective programming methods and the development and operation of a lexicographic weighted goal programming approach, (Bartlett et al, 1976), to resolve the conflict over crop farm development in the Paracatu "Planicie" area, Minas Gerais, Brazil. The

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[1]Linkages to the overall economy are through the prices of capital, agricultural commodity prices, labour, purchased inputs and through institutional constraints involving income tax and agricultural credits.

objective of developing the lexicographic weighted goal programming model (here denominated as GP model) is to analyse the consequences of alternative farm plans and to develop an understanding of trade-offs between the interests of farmers and the interests of Brazilian society (i.e. under the public sector point of view) associated with the rural development of the "Cerrado" region.

7.2 Background to problem

Resource development planning problems, with solutions requiring economic, social and environmental impact analysis, are liable to be regarded as political problems about power in governments, and conflicts of interest between particular groups - rural and urban; rich and poor; landowners and tenants; landowners and environmentalists; the industrialized 'North' and the agrarian 'South'; and so on.

In recent years some improvements have been made in resource development proposals in order to incorporate considerations beyond the traditional concern of project analysis. Such improvements have occurred with the evolution of analysis methods designed to reconcile multiple conflicting goals and objectives subject to technical, financial and environmental constraints, McGregor(1986). Resource development proposals have, also, been improved as a consequence of a

> " growing belief among experimented people that agricultural development projects[2] with top-down 'packages' adapted to local circumstances have not, in general, been spectacularly successful ", Simmonds(1985, pg 61).

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[2]Projects financed by institutions such as World Bank and governments.

In many underdeveloped countries like Brazil, the use of modern agricultural technologies has resulted in some economic achievements by speeding up agricultural growth, but at the same time they have been blamed for accentuating rural inequality and contributing to the conflict between agricultural and environmental objectives, Chaudri and Dasgupta(1985). The question then becomes how to develop appropriate programmes that are sustainable and compatible with the environmental quality goals; and the social, economic and regional development goals ?

Goals for a sustainable development in Paracatu "Planicie", involve conflicts both within the region with respect to each goal, and between the goals themselves.

In this context, sustainable regional development presumes the promotion of generalized objectives such as:

i. efficient allocation of resources;
ii. provision for employment generation and economic growth;
iii. establishment of, and distribution of, income and wealth having social sanction and acceptability; and
iv. sustainable environmental quality.

However, these objectives are so general in scope that they do not offer much help in devising concrete policies. In the real world there are all sorts of conflicting[3] policies and objectives. Any attempt to bring regional development performance more closely in line with any one of the objectives described above, involves trade-offs with the others. Moreover, there is no one "maximizing unit". The multiplicity of units and their interactions with each other do a great deal to

[3]For instance, the development pattern that minimizes environmental damage is unlikely to be one which allows economic growth to be maximized.

complicate the regional development planning process, Hamilton et al(1969) and Rees(1985).

The natural "Cerrado" resource constitutes a capital asset from the point of view of society. Its use produces a stream of returns to Brazilian society through time. Such returns depend on the technological efficiency of the alternative farm systems, their allocative efficiency[4] and the long-term environmental quality and stability goals in practice. Thus, the crucial management task in developing the "Cerrado" is to allocate the stream of returns, mentioned above, in order to maximize expected net social benefits under conditions which are environmentally sustainable.

In this particular study, it would be desirable to develop a multiple objective model at the regional level, that would include all the major effects described in Table 7.1. In practice it is not possible to incorporate all such effects into the GP model because of lack of some appropriate[5] data and information. Nevertheless, the GP model is intended to incorporate the preferences of a "Cerrado" use policy maker by ranking goals and setting priority levels.

7.3 Multiple Objective Programming Methods

Linear programming (LP) is recognised as a powerful and versatile computer-based aid to decision-making because it can provide valuable insights into the nature of resource allocation decisions, Dent et al(1986). Major

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[4]In economic terms, allocative efficiency is concerned with the entire distribution of factors of production and goods or services within an economy, Rees(1985).

[5]Data such as annual cost of cropland erosion (for example: in the USA, in 1982, on-site productivity loss and off-farm damages was estimated in about US$ 2,452 million) and negative effects on ground and surface waters, OECD(1989).

Table 7.1 The Major Effects of New Crop Farm Development

Benefits	Costs
Primary benefits:	Primary costs:
(i) increased agricultural production with improvement in product quality, change in time of sale, change in location of sale, change in production form, reduced transport costs and reduced losses	(i) capital cost of the development
(ii) reduced seasonal variations in the farm business cash flow and low variations in net income flows	(ii) increased production costs e.g. cost of increased fertiliser and electricity
(iii) increased foreign exchange	
External benefits:	External costs:
(i) Technological-physical benefits such as improved healh	(i) Technological-physical costs associated with development e. g. increased soil erosion and sedimentation of water streams and increased concentration of nitrates in stream water
(ii) Pecuniary[a] (financial) benefits benefits to supply and processing industries as measured by multiplier[b]	(ii) Pecuniary (financial) costs capital opportunity costs
Social benefits[c]:	Social costs:
(i) improvement in associativism and general community spirit	(i) displacement of natural pasture used for extensive beef cattle production
(ii) settlement of new farmers in under-used arable land	(ii) displacement of peasants who do not adapt to the new farming systems
(iii) reverse to some extend rural depopulation	
(iv) decentralization of public investments	
(v) increased local service demand	
(vi) security of food supply[d]	
(vii) agrarian reform (transformation of large latifundiums into productive farms	
Visual benefits:	Visual costs:
(i) Landscape benefits green fields in the dry season	(i) Landscape costs reduced natural vegetation
	(ii) displacement of wild life habitat

(a) "Pecuniary or indirect effects are a change in output or utility of a 3rd party due to changes in the level in the demand", Gittinger(1982).

(b) Agriculture increasing dependence in other economic sectors expands the demand for their products.

(c) Most of the above types of contribution are commonly called 'economic' but they have major importance for social relationships within and between "Cerrado" regions, and for regional progress.

(d) Agriculture contributes to the security of food supplies through increases in total production and by trading, both in and between nations. The complemantarity between dryland and irrigated areas increases the security food supply.

limitations of LP are the restriction to solving a single objective (such as maximization of profit or minimisation of cost) and its restriction to common units in determining efficiency.

A range of mathematical programming methods have been suggested to handle problems with multiple noncommensurable objectives. Finding the set of nondominated solutions with such programming methods, can be considered a sound first step of any decision making methodology. These methods have been segmented in three categories, depending on the decision-making setting for which they are best suited and on the information flows that their use requires, Cohon(1978), Mendoza et al(1986), McGregor(1986), and Bare and Mendoza(1988). The descriptions that follow are intended to stress the general approaches of the different methods and aspects of the chosen technique goal programming.

7.3.1 Generating techniques

Generating techniques refer to those approaches whereby the analyst generates the entire set of nondominated solutions without requiring the prior articulation of preferences from the decision maker. A bottom-up information flow is used to generate the set of solutions which are presented to the decision maker to select the best-compromise solution. This type of technique is represented by the weighting and constraint methods and variants of these methods (particularly the multiple objective simplex method).

The weighting method for finding noninferior solutions, combines multiple objectives into a single overall objective function (e.g. maximize $Z(w) = Z_1 + wZ_2$) which with an associated set of constraints, can proceed directly to a solution by using the simplex method. The solution generated is the best compromise solution for the decision-maker who articulated the value of the weight, w. The weights are varied and the simplex method applied to obtain the set of non-inferior solutions. McGregor(1986) stressed that if the weights represent the decision-makers preferences, then a traditional linear program can be used to generate a single 'best' compromise solution.

The constraint method involves the optimization of one objective while all the others are constrained to some value.

Generating techniques imply that a relatively small burden is placed on the decision-maker(s) in terms of supply of information but with problems having more than three objectives, computational burden and the complexity of the results makes their use prohibitive.

7.3.2 Techniques that incorporate preferences

Preference oriented methods rely on prior articulation of preferences by the decision-maker(s). These preferences that are then passed to the analyst for inclusion in the planning model. Such methods are subdivided into classes: non-interative and interative approaches.

7.3.2.1 Non-interactive methods

These methods avoid generating the entire nondominated solution set, but require considerable a priori information that incorporate preferences. Techniques representative of this approach include: goal programming, compromise programming, ELECTRE method and the surrogate worth trade-off method. Some detail about the goal programming technique is presented in the Subsection 7.3.4.

7.3.2.2 Interactive methods

Interactive techniques seek to draw out relevant preference information from decision makers through iterative person-machine or decision maker-analyst interactions, Cohon(1978). In the process, nondominated solutions are generated and submitted to the decision maker for his or her interpretation and additional formulation. Through this interactive process, the decision maker eventually chooses the best-compromise solution. Different interactive techniques such the STEP method, the technique of Geoffrion and a trial and error procedure have been developed. However, McGregor(1986) mentioned that interactive methods do not explicitly capture the trade-offs between objectives because the weights do not reflect a value judgement of the decision maker.

7.3.3 Techniques for multiple-decision-maker problems

Planning problems involving multiple objectives and multiple decision makers are directed at the resolution of conflict among many interest groups and decision makers. These techniques involve welfare economics and political science concepts as well as an operations research basis. Therefore, they are not well developed yet, Mendoza et al(1986).

Cohon(1978) discussed the development of techniques for the aggregation of multiple preference orderings into a single ordering and other approaches for multiple-decision maker problems. However, he stressed that the identifiability of decision-makers is most critical for multiple-decision-maker methods than the other multiple objective programming methods because they require explicit identification of an index of political power or a utility function with each decision maker. Difficulties associated with extracting a single decision maker's preferences are magnified by the number of decision-makers to be involved in any application of these methods.

7.3.4 The chosen goal programming technique

Goal programming is a well known multiple objective programming method and its general aim is simultaneous satisficing of several goals rather than an optimising solution. Goal programming applies a minimum-distance notion of best, i.e. the deviations from the desired targets and what is actually achievable are minimised.

7.3.4.1 Goal programming formulation

The goal programming technique adopt a linear programming formulation as discussed by Cohon(1978, pg 189), which is shown in Figure 7.1.

Considering that weighted deviations reflect the relative importance of the objectives and the relative significance of positive or negative deviations, the mathematical formulation for goal programming becomes

$$\text{minimise } Z = \sum_{i=1}^{k} (w_i \, y_i^+ + v_i \, y_i^-)$$

subject to:

$$f_i(x) - y_i^+ + y_i^- = g_i \qquad (i= 1, 2, \ldots, k)$$

where,

$f_i(x)$ = an objective function,
y_i^+ = a deviational variable measuring the amount of over-attainment of the goal,
y_i^- = a deviational variable measuring the amount of under-attainment of the goal,
g_i = the goal attainment desired for the objective function i,
w_i = the relative weight or penalty cost for over-attainment, and
v_i = the relative weight or penalty cost for under-attainment.

Figure 7.1 Goal Programming Formulation

MANAGEMENT SCHEMES	PRODUCTS (USERS)	DEVIATIONAL VARIABLES		
PRODUCTION RATE FOR GOAL CONSTRAINTS OF VARIABLE RESOURCES	USE RATES FOR GOAL CONSTRAINTS OF VARIABLE RESOURCES	"LINK" MATRIX BETWEEN DEVIATIONAL VARIABLES AND GOAL CONSTRAINTS	$\leq \geq =$	GOAL LEVELS
"LINK" MATRIX BETWEEN PRODUCTION OF "FACTORS" ON FIXED RESOURCES AND MANAGEMENT SCHEMES	NULL SUBMATRIX	NULL SUBMATRIX	$\leq$	FIXED RESOURCES (LAND, SUPPLEMENT)
PRODUCTION RATES OF VARIABLE RESOURCES	USE RATES OF VARIABLE RESOURCES	NULL SUBMATRIX	$\geq$	LOWER LIMIT OF VARIABLE RESOURCES
NULL SUBMATRIX	"LINK" MATRIX BETWEEN USERS AND REQUIREMENTS	NULL SUBMATRIX	$\geq$	QUALITY OF USER (PRODUCT) REQUIREMENT
		OBJECTIVE FUNCTION OF WEIGHTS AND PRIORITY FACTORS FOR THE MINIMIZATION OF THE DEVIATION FROM EACH GOAL		

Source: Bartlett et al(1976) GOAL: Multiple Objective Programming, pg 5.

Thus, the goal programming technique makes it necessary for the decision maker or evaluator to assign values for the goal levels and the relative weightings.

However, two specific variants of the goal programming technique, lexicographic goal programming (LGP) and weighted goal programming (WGP), are widely discussed, Romero and Rehman(1989). LGP is used when attaching pre-emptive weights (weights that are elicited from the decision maker prior to running the model) or absolute weights to the sets of goals situated in different priorities. Hence, the LGP technique assumes that the decision maker can define all the goals relevant to the decision and give pre-emptive priorities to the goals. A characteristic of the LGP technique is that highest priority goals are satisfied first, and only then are lower priorities considered. On the other hand the WGP technique is used when non-pre-emptive weights are used on goals. It considers all goals simultaneously within a composite objective function composed of the sum of all deviations among the goals and their aspiration levels. WGP weights the goals according to relative weights and includes all the goals in a single objective function.

7.3.4.2 Limitations and strength goal programming technique

Goal programming has been found to be a successful tool to handle a significant number of landuse decision problems (Panagiotakopoulos(1975), Romero and Rehman(1985), Bishop et al(1977), Barnett et al(1982) and McGregor(1986)). Goal programming was found to have the following advantages by some these writers:

i. it can incorporate the advantages of generating techniques; and
ii. it presents computational efficiency in comparison to the generating techniques.

However, although goal programming is a powerful tool which combines the logic of optimisation in LP with the decision maker's desire to satisfy several goals, in certain situations, it presents limitations to planning problems with multiple objectives. These are:

i. problems in identifying decision makers and their perceptions of the range of choice and feasibility;

ii. generation of identical solutions to those provided by LP for a given problem (there is the risk that the analyst judges the technique as redundant tool);

iii. when the number of priorities is larger than 5, goals in the lowest priorities can become redundant;

iv. although trade-offs between goals can take place within a given priority they cannot be traded off across the boundaries of different priorities (sensitivity analyses should be conducted on the goals and weights to exam the change in the solution and overcome this), Cohon(1978, pg 190);

v. the possibility of non-efficient optimal solutions when the target levels have been set at very pessimistic levels. McGregor(1986) suggested that in such situations the analyst should carry out a parametric analysis of the aspirations levels used in the model with the aiming of verifying goal achievements;

vi. in the public sector a number of decision-makers and/or evaluators set the goal attainment levels and penalty weights for non-attainment;

vii. incorrect value judgements can be obtained from the decision-makers because they lack prior knowledge of the likely trade-offs. (this is stressed by McGregor(1986, pg 135); and

viii. the theoretical problem of maximising the achievement function is not the same as optimising the utility function of a decision maker.

7.4 Structure of the GP Model

The GP model (described below) incorporates outcomes from the CECROPF risk model combined with basic data about the Paracatu "Planicie" area and experimental data about soil erosion in the CPAC/EMBRAPA station. This ensures that an integrated rural development project or programme can be evaluated by its performance, and by the extent to which it fulfils the economic, social, environmental quality and political objectives set for the Brazilian society.

The GP model presented here is a demonstration of an approach to reconcile conflicts resulting from agricultural development of the natural "Cerrado" in the Paracatu "Planicie" area. The model is designed to represent issues at the regional level. It follows the formulation mentioned above (section 7.3.4.1).

Relevant goals for an agricultural development of the Paracatu "Planicie" area are defined and ordered in terms of priority levels, prior to running the GP model. The matrix used in the goal program (see Table 7.2) is composed of goals and resource, or non-goal constraints. Each defined and ranked[6] goal constraint may be assigned a positive or a negative deviational variable (Table 7.3), or both, Bartlett et al(1976).

Major features of farm systems generated by the CECROPF model which are incorporated in the matrix of the GP model are described in Appendix 6. The GP model is by no means comprehensive because important information such as erosion costs of the different Paracatu "Planicie" soil

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[6]The goals are ranked according to priority.

Table 7.2 Part I of the Goal Programming Model for Paracatu's "Planicie" Area

i) Problem formulation matrix

ACTIVITIES: Farm Systems (generated by CECROPF model) — X014 to X016; Soil losses, X004 to X007, per hectare

Constraint or goal Row number	Description	X014 Fs01	X015 Fs02	X016 Fs03	X001 Ag inv credit	X002 Inv in soils	X003 Inv in mach.	X004 Soil losses in rice crops	X005 in maize crops	X006 in soya crops	X007 Total	X008 Capital Initial	X009 Market	X010 Generated	X011 Labour Hired	X012 Consumption Discretionary	X013 Farmers Number	Type of inequality	Unit(1)	RHS Value
R001	LVA soil	27.	42.	55.														L	ha	37394
R002	LVE soil	70.	110.	110.														L	ha	112182
R003	LHi soil	28.	35.	53.75														L	ha	37394
R004	Inv. in soil	12.5998	19.0506	22.363	-1													E	OTN	0
R005	Inv. in mach.	7.	7.	7.		-1												E	OTN	0
R006	Total credit				1	1	-1											E	OTN	0
R007	Rice crops	-157.3	-248.2	-388.9				1										E	t	0
R008	Maize crops	-132.	-219.	-291.9					1									E	t	0
R009	Soybean crops	-620.1	-819.	-934.1						1								E	t	0
R010	Soil losses							-8	-29	-9	1							E	t	0
R011	Hired(2) labour	5.069	7.5899	9.86											-1			E	hs	0
R012	Discretionary cons.	.477	.4678	.3889												-1		E	OTN	0
R013	Initial capital	2.5	2.5	2.5								-1						E	OTN	0
R014	Market capital	.7359	1.	1.									-1					E	OTN	0
R015	Net revenue(3)	-6.3152	-8.6638	-11.0735								1		1				E	OTN	0
R016	Selec. farm system	1	1	1													-1	E	Fz	0
R017	Public capital						1											G	OTN	0
R018	Initial capital											1						G	OTN	0
R019	Hired labour														1			L	hs	99999999
R020	Total disc. cons.															1		G	OTN	100(4)
R021	Number of farmers																1	L	Far	99999999
R022	Market capital												1					L	OTN	99999999
R023	Regional income													1				L	OTN	99999999
R024	Total soil losses										1							G	t	0

(1) ha = hectares, OTN = "Ordem do Tesouro Nacional", TD = tractor driver, hs = hours, and Fz = farmers' number.
(2) Hired labour is expressed in 2200 hours or 1 tractor operator contracted per one year. It includes seasonal labour hired on a daily (8 hs/day) basis + employed tractor operator(s) hired on a monthly (200 hs/month) basis.
(3) Net revenue = Final working capital - Initial working capital + (final net asset excluding the original value of the land).
(4) The total discretionary consumption of all farmers in the 10 and half years, is expressed in 1000 OTN. This is a parameter to be tested.
Note: The resources of the rows R004, R005, R006, R012, R013, R014, R015, R017, R018, R020, R022 and R023 are expressed in 1000 OTN.

Table 7.3 Part II of the Goal Programming Model for Paracatu's "Planicie" Area

ii) Goal summary

Constraint row number	Priority weight	Type of achieveievement	Differential weight	Type of inequality	Goal or RHS Unit	Value	Goal description
R017	P1	Over	4	G (min)	OTN	0	Public program budget
R018	P1	Over	3	G (min)	OTN	0	Farmer own capital to start the farm
R023	P1	Under	2	L (max)	OTN	99999999	Regional income
R022	P1	Under	1	L (max)	OTN	99999999	Market capital
R020	P1	Over	1	G (min)	OTN	100	Disc. consumption
R024	P2	Over	1	G (min)	t	0	Total soil losses
R019	P3	Under	1	L (max)	hs	99999999	Hired labour
R001	P4	Under	1	L (max)	ha	37394	70% of the LVA available land
R002	P4	Under	1	L (max)	ha	112182	70% of the LVE available land
R003	P4	Under	1	L (max)	ha	37394	70% of the LHi available land
R021	P5	Under	1	L (max)	Fz	99999999	Number of farmers

Note: All other constraints (R004, R005, R006, R007, R008, R009, R010, R011, R012, R013, R014, R015, R016) are non-goal constraints.

types and the quantity of water available for irrigation[7] were not included. However, the model developed here is illustrative of an approach which could be adopted to resolve similar regional planning scenarios. The GP model involves 24 constraints, 23 activities or variables and 11 goals ordered in 5 priority levels as shown in Tables 7.2 and 7.3.

7.4.1 Goals

7.4.1.1 Paracatu "Planicie" land use/environmental goals

Following the physical description of the Paracatu district presented by Carneiro(1986), it is assumed that up to 70 percent of the 267,100 hectares which form the Paracatu "Planicie" area[8], are still covered with natural "Cerrado" vegetation and its soil types are distributed in: 20 percent "Latossolo Vermelho Amarelo" (LVA), 60 percent "Latossolo Vermelho Escuro" (LVE) and 20 percent "Latossolo Hidromorfo" (LHi). Moreover, it is assumed that some sort of ordered agrarian reform in the area is acceptable to the local people. The new farm systems (see Table 7.2) were projected with a maximum farm size of 218.75 hectares, in an effort to represent acceptable land use options, necessary (see Chapter 3) for agricultural development of the "Planicie" area.

Each alternative crop farm system includes a natural vegetation reserve corresponding to 20 percent of total farm area (see Appendix 6). This ensures that at least 20 percent of the natural "Cerrado" resource in the Paracatu "Planicie" area will be kept as an ecological

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[7]Given the availability of water from Paracatu "Planicie" rivers, in the alternative farm systems incorporated in the GP model there are projected irrigation sub-systems of up to 20 hectares.

[8]In 1986 80 percent of the Paracatu "Planicie" area was covered with natural "Cerrado" vegetation, Carneiro(1986).

reserve and reflects legal commitments for such reserves. Moreover, it is presumed that an environmental impact assessment must precede any new proposals for rural development or projects in the "Cerrado" sub-regions. Historically, this fundamental aspect of resource development has not been included in the agricultural planning process as applied in Brazil, Resk and Gomes(1989).

Kooten, Weisensel and Jong(1988) estimated the costs of soil erosion in Saskatchewan in Canada, taking into consideration the cost of technological inputs required to minimise soil losses. Soil conservation measures were compared in a "with/without" analysis with allowing erosion to continue unabated. Costs associated with erosion included damage to growing crops, reduction in potential yield, removal of land from production and increased power requirements for machinery operations. Although "Cerrado" soil erosion costs have not been estimated, Resk and Gomes(1989) have reported that at CPAC/EMBRAPA station in Brasilia, a LVE soil type, uncovered, with 5 percent of slope, 45 percent of silt, had an erosion index of 5.3 millimetres or a loss of 53 tonnes of arable soil per hectare per year. Measurements of erosion in LVA and LHi soil types were not presented. However, assuming that the LVA, LVE and LHi soil types have similar physical conditions and that all soil areas incorporated in the production process will be always under cultivation during the rainy season, it is fair to assume that the parameters of soil erosion presented in the Table 7.4 are appropriate. Such data allow a better representation of the land use/environmental impacts when incorporated in the GP model. Different quantities of soil losses can be assessed depending on land use levels (see Figure 8.2 of Chapter 8).

Table 7.4 Soil and Water Losses[a] over a Yearly Period in a LVE Soil under Different Crops

		soil condition[b] in the rainy season				
Losse types	unit[c]	uncovered	maize crop	rice crop	soybean crop	pasture crop
soil losses	t/ha	53	29	8	9	0.1
water losses	mm	293	264	257	180	16
infiltration	%	76	79	86	87	90

Source: "Planejamento Agropecuario a Nivel de Microbacias Hidrograficas na Regiao dos Cerrados", VII Simposio sobre o Cerrado, Brasilia, DF, Brasil, Resk and Gomes(1989).
[a]Everages of six years data.
[b]Soil slope = 5.5%.
[c]Metric tonnes per hectare (tm/ha), millimitre (mm) and percentage (%).

The GP model presented in the Table 7.2 incorporates three land use goals set with priority level 4 and weight 1; and one environmental quality goal relating to soil conservation or more specifically, the minimisation of total soil losses (goal set with priority level 2 and weight 1). The coefficient for soil erosion presented by soybean crop is used to represent the irrigated soils with a rotation of soybean-wheat. This is assumed because wheat crops are grown in the dry season. The rice crop is the most interesting because it presents the lowest erosion index among the alternative crops under consideration (see Table 7.4).

Table 7.3 shows the total number of hectares of soil that are cultivated with rice, maize and soybean crops during the 10 1/2 years of each selected farm system projected by the CECROPF model. The goal relating to soil erosion is, of course, to minimize total soil losses. To reflect this, the goal level is set at zero and an over-achievement of the goal is allowed.

7.4.1.2 Farm Family goals

There are reasons to encourage agricultural land ownership. In Britain, Gasson and Hill(1984) have presented such reasons in the following order: residence; inheritance; social responsibility; amenity; love of the land; tax rebate; expertise in, and enjoyment of, estate management; and enjoyment of other resources such as minerals or timber. Some of these reasons also apply to Brazil. The farm income is the goal maximized in the CECROPF (farm level) model. The farm family goals included in the GP (regional level) model are: maximization of the discretionary consumption level of the farm family (which is set with priority level 1 and weight 1); and the minimisation of initial capital to start the farm business (set with priority level 1 and weight 3).

7.4.1.3 Social goals

The social goals set in the GP model are: to maximise job creation and to maximise the number of new farmers settled in the Paracatu "Planicie" area. The job creation goal is expressed in hours of hired labour where the seasonal labour contracted on a daily basis offer 8 hours of work per day and the contracted labour on a monthly basis offers 2,200 hours per year (or 200 hours per month). The hired labour goal is set to maximise an underachievement with priority level 3 and weight 1. The number of new farmers is a goal that can be underachieved and it is set with priority level 5 and weight 1.

7.4.1.4 Economic goals

The following three economic goals are used in the model; minimisation of the capital required from the public program budget; maximization of the regional income generated; and the maximization of the market capital used for developing new crop farms. The public program budget goal can be underachieved (set with priority level 1 and weight 4) and the regional income goal (set with priority level 1 and weight 2) and the market capital goal (set with priority level 1 and weight 1) must be overachieved.

7.4.2 Constraints

All the GP model constraints are described in the Table 7.2. The model includes:

- three constraints (R001 to R003) which relate to the total availability of each soil type in the Paracatu

"Planicie" area and the soil requirements of each alternative farm system[9];

. three goal constraints (R004 to R006) which relate to the agricultural credit requirements for investments in soil and machinery by the alternative farm systems;
. four constraints (R007 to R010) associated with soil losses, which relate the total area cultivated with each alternative crop;
. one constraint (R011) which restricts the total hired labour by the alternative farm systems;
. one constraint (R012) which relates to the total discretionary consumption by the alternative farm systems;
. one constraint (R013) which relates to the farmer's initial capital required by the alternative farm systems;
. one constraint (R014) which relates to the market capital required by the alternative farm systems;
. one constraint (R015) which relates to the net revenue of the alternative farm systems;
. one constraint (R016) which relates to the number of alternative farm systems to be selected; and
. eight goal constraints (R017 to R024) as specified in the goal summary of Table 7.3.

7.4.3 Activities

The activities or variables X001 to X013 included in the GP model are described with detail in the Table 7.2 shown above. The detail of the activities X014 to X016 are presented in the Appendix 6.

7.5 Running the GP Model

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[9]See Appendix 6.

The GOAL[10] algorithm is used to analyse the trade-offs incorporated into the GP model formulation and to present a compromise solution (see Chapter 8). Such trade-offs result in conflicts involving, for instance, increases in the regional income and increases in the requirements of public capital. This is discussed in the Chapter 8.

[10]Bartlett et al(1976) developed the goal programming software (GOAL) in FORTRAN, following the main concept from goal programming for decision analysis adopted by Lee(1972).

Chapter 8 Discussion of Modelling and Results

8. Discussion of Modelling and Results

8.1 Introduction

This chapter presents and analyses the GP model run results and the implications of the Paracatu "Planicie" area agricultural development for regional development. Furthermore, the effectiveness of the modelling results, limitations of the present study and future development are discussed.

8.2 Results of Regional Planning

Although a great effort was made to develop a comprehensive regional planning framework, this section presents no more than an illustration of its potential. Firstly, the GP model is applied to select the most appropriate farming systems with respect to different policies (i.e. different goal levels and priorities). Then the requirements of direct investments are analysed, and the generation of jobs, financial output and soil losses from the farms are estimated.

8.2.1 Farming systems for the region

Three basic farming systems were incorporated into the GP model. Appendix 6 presents their areas as:

i. farming system 1 with 100 hectares of crop land and 25 hectares for ecological reserve;
ii. farming system 2 with 150 hectares of crop land and 37.5 hectares for ecological reserve; and
iii. farming system 3 with 175 hectares of crop land and 43.75 hectares for ecological reserve.

Results of the GP model and results of an extended GP model are described below.

8.2.1.1 Base runs of the GP model

Some base runs of the GP model were necessary to identify the maximum level of the total discretionary consumption goal. The optimal value of the GP model decision variables of the first (run 01a) and the best (run 01b) base runs are presented in Table 8.1 below. Figures A7.1 and A7.2 of Appendix 7 present the input data and the results of the best base run results of the GP model.

Table 8.1 Optimal Value of the GP Model Decision Variables (Base Runs)

Variable	description	(unit)	run 01a amount	run 01b amount
X014	Farm system 01	number	209.64	1335.43
X015	Farm system 02	number	0.00	0.00
X016	Farm system 03	number	0.00	0.00
X001	Inv. in soils	1000 OTN	2641.47	16826.15
X002	Inv. in mach.	1000 OTN	1467.51	9348.01
X003	Inv. total	1000 OTN	4108.97	26174.16
X004	Total area (rice)	ha	32976.94	210063.10
X005	Total area (maize)	ha	27672.96	176276.70
X006	Total area (soya)	ha	129999.99	828100.00
X007	Total soil losses	t	2236331.25	14245430.00
X008	Initial capital	1000 OTN	524.11	3338.57
X009	Market capital	1000 OTN	154.28	982.74
X010	Generated capital	1000 OTN	799.83	5094.93
X011	Hired labour	1 man year	1062.68	6769.29
X012	Disc. consumption	1000 OTN	100.00	637.00
X013	Number of farms	number	209.64	1335.43

The best base run results of the GP model show that the incorporation of three different farming systems into the GP model is not enough to demonstrate the potential of the LGP technique. The selected farming system 1 with the adjusted maximum total discretionary consumption goal level (see Figure A7.2 of Appendix 7 and variable X012 in Table 8.1) and a total of 1335 farms, can incorporate no more than 89 percent of the Paracatu "Planicie" area.

However, once the ecological reserves of the farming systems mentioned above are excluded from the CECROPF model formulation, the specification of the ecological reserve area of each soil type in each farming system shown in Table A6.1 of Appendix 6 can be varied. Thus, given the limitation of time, a way to project other different farming systems which generate the same CECROPF model results presented in Table A6.2 of Appendix 6 is by varying the ecological reserve area[1] in each one of the soil type areas without changing the total and crop land areas of the farming systems mentioned above (see Figure A7.3 of Appendix 7).

Section 8.2.1.2 below presents the results of the GP model extended to incorporate a total of nine alternative farming systems and two additional irrigation constraints[2] as described in the Figure A7.3 of Appendix 7.

8.2.1.2 Results of the extended GP model

To analyse trade offs such as those involving the goals: public capital requirement, number of farmers and number of man years, different scenarios are analysed below.

i. The effects of changing goal priorities

Goal priority changes in the extended GP model are shown in Table A7.2 of Appendix 7. The results, summarised in Table A7.3 of Appendix 7, show that the formulation of

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(1)It was assumed that the farmer will negotiate the ecological reserve of his farm independently of the other farm investments with are incorporated within the CECROPF model.

(2)Any one of the farming systems incorporated into the GP model is suppose to include an irrigatable area (15 hectares of the LVE soil area and 20 hectares of the LHi soil area).

the model was not flexible enough to allow significant effects on the choice of farming systems. For example:

. The farming systems with smallest area (125 hectares) were selected in all four runs.
. The number of farming systems and many other variables did not presented significant changes.

Thus, other scenarios were analysed as described below.

ii. The effects of changing goal levels

Changes in the investment credit goal level were analysed by introducing flexibility in the deviation (under or overachievement) allowed in the total discretionary consumption goal of the extended GP model. Details of the results are presented in Tables 8.2 and 8.3. Figures 8.1 summarises the most significant effects of changes in the availability of such a scarce public resource. For instance, the choice of farming systems involves trade-offs of options such as a larger number of farmers generating lower regional income (generated capital) with higher total discretionary consumption; or a smaller number of farmers generating higher regional income with lower total discretionary consumption and lower total soil losses.

Considering alternative farm systems for Paracatu "Planicie" area, a brief discussion on the resource requirements, the employment, the financial output from farms and the soil losses is presented below.

8.2.2 Direct investments

Direct investments involve public and market capital. Public capital was linked with investment in soils and machinery, irrigation systems and market capital was linked with the cash requirements.

Table 8.2 Goal Attainment Levels and Priority and Weight Attributes Used in Extended GP Model Runs
(effects of changing goal levels).

goal description	(unit)	run11 goal level	run11 goal type	run11 deviation allowed	run11 priority and weight attrib.[1]	run15 goal level	run16 goal level	run17 goal level	run18 goal level	run19 goal level	run20 goal level
Soil LVA	ha	37394.0	max	under	4 (1)	37394.0	37394.0	37394.0	37394.0	37394.0	37394.0
Soil LVE	ha	112182.0	max	under	4 (1)	112182.0	112182.0	112182.0	112182.0	112182.0	112182.0
Soil LHi	ha	37394.0	max	under	4 (1)	37394.0	37394.0	37394.0	37394.0	37394.0	37394.0
Inv credit	1000 OTN	0.0[2]	min	over	1 (4)	25000.0	20000.0	15000.0	10000.0	5000.0	28500.0
Initial capital	1000 OTN	0.0	min	over	1 (3)	0.0	0.0	0.0	0.0	0.0	0.0
Hired labour	1 man year	99999999.0	max	under	3 (1)	99999999.0	99999999.0	99999999.0	99999999.0	99999999.0	99999999.0
Total disc. cons.	1000 OTN	707.8[3]	min	over	1 (1)	707.8	707.8	707.8	707.8	707.8	707.8
Number of farmers	farms	99999999.0	max	under	5 (1)	99999999.0	99999999.0	99999999.0	99999999.0	99999999.0	99999999.0
Market capital	1000 OTN	99999999.0	max	under	1 (1)	99999999.0	99999999.0	99999999.0	99999999.0	99999999.0	99999999.0
Regional income	1000 OTN	99999999.0	max	under	1 (2)	99999999.0	99999999.0	99999999.0	99999999.0	99999999.0	99999999.0
Total soil losses	t	0.0	min	over	2 (1)	0.0	0.0	0.0	0.0	0.0	0.0
Max ir. area - LVE soil	ha	26000.0[4]	max	under	4 (2)	26000.0	26000.0	26000.0	26000.0	26000.0	26000.0
Max ir. area - LHi soil	ha	34000.0[4]	max	under	4 (2)	34000.0	34000.0	34000.0	34000.0	34000.0	34000.0

(1) Values in brackets are the differential weights associated with the priority levels.
(2) Agricultural investment credit goal (run 11) was changed in the subsequent runs. Its goal type was changed from minimization to maximization and over to under-achievement deviations were allowed.
(3) The total discretionary consumption goal was changed to allow under and overachievements.
(4) Up to 1700 farming systems were allowed.

Table 8.3 Optimal Value of Decision Variables of Extended GP Model Runs (effect of changing goal levels).

Variable	description	(unit)	run 11 amount	run 15 amount	run 16 amount	run 17 amount	run 18 amount	run 19 amount	run 20 amount
X014	Farm system 01	number	652.66	0.00	0.00	0.00	0.00	0.00	372.45
X016	Farm system 03	number	0.00	53.36	0.00	510.85	340.56	170.28	130.65
X017	Farm system 04	number	0.00	0.00	0.00	0.00	0.00	0.00	0.00
X020	Farm system 07	number	831.20	553.85	0.00	0.00	0.00	0.00	833.84
X022	Farm system 09	number	0.00	428.35	681.13	0.00	0.00	0.00	34.77
X001	Inv. in soils	1000 OTN	18696.31	17751.02	15232.09	11424.07	7616.05	3808.02	18898.11
X002	Inv. in mach.	1000 OTN	10387.00	7248.98	4767.90	3575.93	2383.95	1191.98	9601.89
X003	Inv. total	1000 OTN	29083.31	25000.00	20000.00	15000.00	10000.00	5000.00	28500.00
X004	Total area (rice)	ha	233410.80	274459.70	264891.20	198668.40	132445.60	66222.79	254078.40
X005	Total area (maize)	ha	195869.20	213721.00	198821.60	149116.20	99410.80	49705.40	207514.10
X006	Total area (soya)	ha	920139.90	793414.10	636242.80	477182.10	318121.40	159060.70	902530.60
X007	Total soil losses	t	15828750.00	15534310.00	13611140.00	10208360.00	6805571.00	3402786.00	16173310.00
X008	Initial capital	1000 OTN	3709.64	2588.92	1702.82	1277.12	851.41	425.71	3429.25
X009	Market capital	1000 OTN	1091.97	889.30	681.13	510.85	340.56	170.28	1053.12
X010	Generated capital	1000 OTN	5661.21	6243.04	5839.66	4379.75	2919.83	1459.92	6020.40
X011	Hired labour	1 man year	7521.67	7531.17	6679.15	5009.37	3339.58	1669.79	7736.71
X012	Disc. consumption	1000 OTN	707.80	451.53	264.89	198.67	132.45	66.22	639.73
X013	Number of farms	number	1483.86	1035.57	681.13	510.85	340.56	170.28	1371.70

8.2.2.1 Agricultural investment credit

Each one extended GP model run (see Table 8.3) included a different public capital level. The lowest and the highest public capital requirements under consideration are 5000. and 29083.31 OTN respectively. The inclusion of 1483 farms of 125 hectares would require the highest public capital level. Using the Table 8.3 data and Figure 8.1 a policy maker could get a good insight on the most appropriate investment decision.

Investments in soils (preparation and fertility correction) require large amounts of public capital. This is illustrated by variable X001 in the Table 8.3.

The farming systems included in the extended GP model are not large enough to support the acquisition of tractors and/or harvesters. This is the reason why the total investments in soils (Table 8.3) are higher than the total investments in machinery.

8.2.2.3 Market capital

Market capital requirements are obviously low (see Table 8.3) of the high market interest rates involved (2 percent per month).

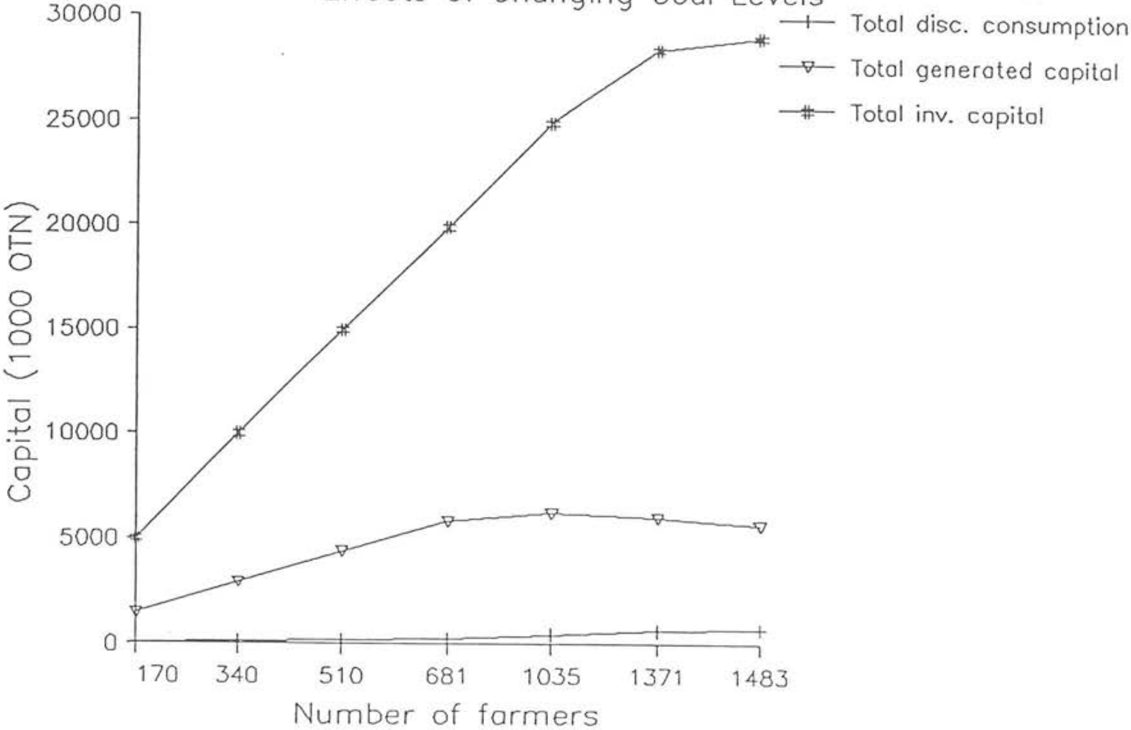
8.2.3 Employment

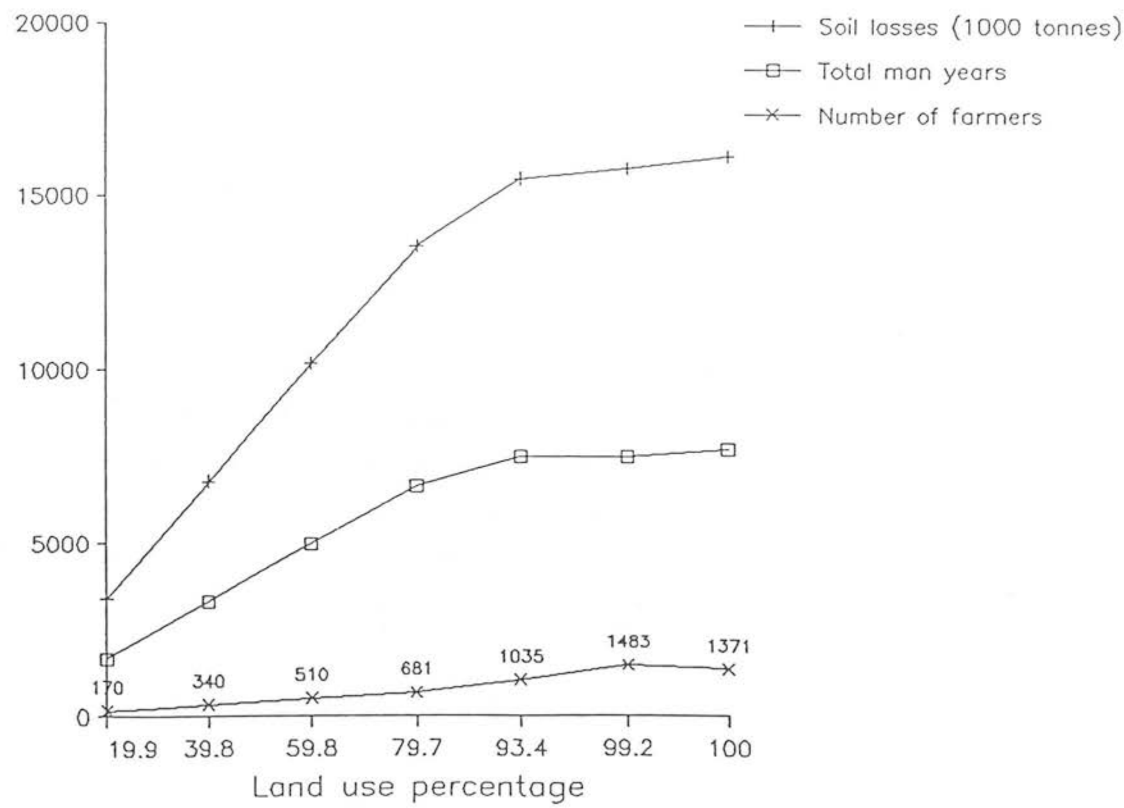
Hired labour is a variable that did not change significantly when the number of farms varied from 681 to 1483. This is a variable to be linked with the total public capital requirement, the number of farms and the total discretionary consumption variables.

8.2.4 Financial output from farms

Figure 8.1: Extended GP Model Run Results

Effects of Changing Goal Levels





The financial output from farms depends on the agricultural production. However, the amount of generated capital and the amount of discretionary consumption are the most important final results.

8.2.5 Soil losses

The total soil losses depend on the percentage of land used. In the GP model it was included as complementary information. Figure 8.1 illustrates well how soil losses increase with increases in the proportion of land used.

8.3 Implications for Regional Development

SUDECO(1985) reported that any agricultural development program for the "Cerrado" must be incorporated within a regional development plan. It suggested the implementation of farm projects emphasizing agrarian reform where large latifundiums should be split into farm units of between 50 and 500 hectares. It discussed aspects relating to land legislation and other factors important in implementing any rural development program within the "Cerrado" region.

However, the development of agricultural systems by implementing new crop farms according to the available technological packages in Brazil, presents implications for regional development such as a public capital requirement for farm development, basic infrastructure and environmental protection; increases in the agricultural output and tax generation; and expansion of agricultural input and output markets.

8.3.1 Rural development requirement

Farm development must be involved in a wide rural development process. The rural development requirement for the farm development of the Paracatu "Planicie" area includes important factors such as: subsidy, market and cooperative of the local farmers.

8.3.1.1 Subsidy

Alston et al(1990) mentioned that in USA, the direct social opportunity cost of subsidy payments within farm programs is likely to be in the range of $1.20 to $1.50 per one dollar of government spending. This shows that the allocation of public capital for farm programs must be analysed taking into consideration other development projects.

Momma(1985) showed that the financial results of a farm development project financed by the PRODECER program were positive; i.e. the subsidy payments would be covered by the amount of tax generated during the 11 year period required for the implementation of such a program.

Although tax generation is a positive outcome of such a crop farm development project, only the amount of public capital required for agricultural investments is quantified (see Figure 8.1), together with the percentage of subsidy involved in its repayment. The amount of public capital projected for such a farm development of the Paracatu "Planicie" area is illustrated in Figure 8.1(3) and the real subsidy (for a real market rate of 12 percent) rate is 13.2 percent per year.

8.3.1.2 Market

(3)A projected amount of 1,000 OTN corresponds to an estimate of about US$ 75,000.

Paracatu District is 220 km from Brasilia and 550 km from Belo Horizonte. It is between these two metropolitan centres.

The agricultural input and output markets in Paracatu district are not developed yet. However, such markets are developing rapidly with the expantion of the Brazilian Federal District and its markets. This is also a consequence of some local farm developments and improvements in the basic infrastructure (such as roads, telecommunications and energy), public services, etc.

8.3.1.3 Cooperative of the local farmers

The planning framework developed here assumes that the local new farmers will form a cooperative to supply services such as: input acquisition, mechanical services, product processing and marketing. The CECROPF model results showed that for farming systems up to 218.75 hectares the acquisition of tractors was not economically viable[(4)]. Therefore, it is assumed that a local cooperative would provide the option for machinery hire.

8.3.2 Other general considerations

i. Employment and housing

Paracatu "Planicie" area is about 80 km away from the Paracatu city. Therefore, the labour force to be employed by the new crop farmers needs housing, health services, schools and other local facilities mentioned below.

ii. Education

[(4)]The acquisition of tractor by farmer is a issue to be studied by exploring extensively the CECROPF model. However, this was not possible in this study.

Education of the Brazilian rural population is a serious problem that has contributed to the accelerated migration of rural populations to the cities.

The Paracatu district council is responsible for the provision of schools in its rural area. Therefore, this involves a political decision to be considered in the design of any rural development project.

iii. Local facilities

Many socio-economic changes occur with the farm development of a natural "Cerrado" area. The necessity for local cultural institutions such as a church; a club (where the people can practice sports, organize meetings, exchange information, etc), health services and other facilities is an important element to be considered in comprehensive rural planning.

iv. Agricultural output

Agricultural output has an important multiplier effect on the regional economy that must be studied and included in any analysis which compares an agricultural project with other investment alternatives. In the practical implementation of the planning framework developed here, such a multiplier effect can be incorporated into an extended GP model.

v. Basic infrastructure

The Paracatu district has a reasonable infrastructure. The Brazilian Federal District is the nearest market. In recent years its roads, and telecommunications, banks, schools, hospitals, legal and agricultural extension services have improved. However, most of the investment in infrastructure is oriented to the urban areas. For instance, the supply of electricity, which is crucial for irrigation, is very deficient in the rural area.

vi. Environment

Increases in agricultural production in any part of the world result in environmental impacts. However, the intensity of negative environmental impacts of a farm development project depend basically upon the technological packages to be adopted in such a project.

Due to the growing evidence of environmental and health risks from agrochemicals, low-input agriculture (LIA) should be emphasized in any new research programs on alternative farming systems. However, Daberkow et al(1988) stressed that the spread of LIA is difficult under existing economic conditions in USA. For developing countries like Brazil where the green revolution approach has been emphasized, this question is more difficult to discuss due to their economic situation and the availability of agricultural technologies[5] to develop poor soils.

The soil erosion problem is one visible effect of any farm development in the "Cerrado" region, and this was included in the results described above. However, for more detail on environmental impacts, an environmental impact assessment (EIA) must be carried out by experts. Pearce et al(1989) stressed that an EIA is a basic requirement for integrating sustainability into a cost-benefit analysis framework.

8.4 Effectiveness of the Modelling Results

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[5]Technology is not a 'free gift' - it is developed with its own array of environmental problems, Pearce et al(1989).

Chapter 1 above stated that research should be carried out in an interdisciplinary manner to explore investment alternatives for the "Cerrado" agricultural development. Thus, the modelling approach applied in this study involves an effort to incorporate the strength of different techniques within a comprehensive planning framework (which includes the development of agricultural systems as the crucial component for the rural development of the Brazilian "Cerrado" region), designed with the purpose of supporting rural development policy-makers.

However, the potential of any modelling approach depends (amongst other things) upon the modeller's abilities, data availability and other resources, and assumptions incorporated into the model components to overcome natural difficulties in mimicking real world problems. Forester(1968) mentioned that any model presents limitations of use, but for many problem situations the modelling approach is the most appropriate way to explore alternative solutions.

This study has developed a methodology which provides insights (i.e. plans farming systems and selects the most appropriate one) for rural planning of the Brazilian "Cerrado" region. However, the effectiveness of such a methodology as a policy analysis tool depends on its practical implementation where the assumptions in the planning framework and data problems can be adequately considered.

8.4.1 Assumptions in the planning framework

The essential issue in the planning framework developed here is not so much the assemblage of any of the models incorporated into it, but rather the development of a participatory modelling process. This process - which entails a logic between several complementary models - can be seen as a basic feature to speed up research projects on alternative agricultural systems for the rural development of the "Cerrado" region. It involved the establishment of many assumptions described in the four previous chapters.

Different sources of information include publications, agricultural advisers and other experts in subjects relevant to solving the problem under consideration, and were useful in this study.

The development of such a planning framework followed the point of view that a set of models incorporating a variety of assumptions, principles and hypotheses is a more solid basis for policymaking than a single model, Greenberger et al(1976). Therefore, assumptions such as:

i. farm production cost budgets expressed in OTN, (according to estimations carried out by Brazilian agricultural advisers in 1988) are appropriate for incorporation into the multiple period CECROPF model;
ii. the product price series expressed in OTN is appropriate for the adjustment of forecasting models;
iii. ten percent discount rate is appropriate for use in the CECROPF model cash flow;
iv. the representation of the first four years of the CECROPF model matrix on a monthly basis is appropriate (in terms of financial detail) for the Brazilian farm planning purpose; and
v. the sales of agricultural products after the fourth year of the farm development are satisfactorily represented by forecasted prices for each specific product for July of each subsequent (7^{th} to 11^{th}) year;

will be better explored in a practical implementation of such a planning framework.

8.4.2 Data problems

In any modelling process assumptions are required to mimic the reference system. However, it is the use of data that provide a tangible link between a model and its reference system, and a means for gaining confidence in the model and its results.

Data are crucial elements for the effectiveness of any modelling effort. In this study some parameters such as crop yields were poorly predicted, but the methodological purpose was achieved.

Brazilian historical data such as those involving weather and product prices were not easily used because of data generation (accuracy, continuity of the time series and economic instability) and reliability problems.

Brazilian experimental data were limited as is discussed below. This study provided some indications in terms of agricultural research priorities concerning rice, maize, wheat and soybean crops for the "Cerrado" region.

8.5 Limitations of the Present Study and Future Development

In a planning framework as this developed here, it is expected that data availability will present limitations. Brazil is a developing country with scarce and unelaborated data and information for planning. These and other computational resource limitations are discussed below. Future development is mentioned in this section as well in the next Chapter 9.

8.5.1 Data validation of crop results

This study is indicative of kind of the results that may be achieved. It is the development of a methodology. Because the crop simulation results have not been locally validated and calibrated, the subsequent planning methodology can only be of general interest.

Data for validation/calibration relate to soils, climate and experimental results from specific cultivars. Appendix 4 of this thesis presents some other considerations with respect to Brazilian experimental data.

8.5.2 Price series forecasting

Price forecasting is a difficult task under any circumstances. However, for the Brazilian economic conditions, price forecasting is more difficult as is shown in Appendix 2 of this thesis. In future studies on agricultural product price series in Brazil, the comparison of forecasting models adjusted by using price series expressed in dollars and in Brazilian National Treasury Bill (as in this study) could provide useful information for the Brazilian agricultural policy-makers.

8.5.3 Computer time for running the CECROPF model risk (MOTAD) version

In an academic environment when a specific research project is conducted by a single student as in a thesis, the allocation of time for model applications must be balanced with many other modelling aspects.

Models such the CECROPF model requires a mainframe computer with an appropriate mathematical programming software. LINDO was chosen to run CECROPF model because it is a well known software in the academic environment. However, its use was not an easy task due to approximation problems in the solution of the CECROPF model's large matrix, and the extensive processing time requirement for each run (see Appendix 6).

8.5.4 Results generated by the GOAL software

GOAL software can produce useful solutions - Appendix 7 but does not represent a fully professional software package. Most interesting results are generated by re-running problems in a sensitivity analysis framework since output data for any problem is much more restricted than from linear programming.

Chapter 9 Conclusion

9. Conclusion

The challenge of developing a suitable planning framework for analysing the incorporation of a "Cerrado" natural vegetation area into commercial crop farms is related to the operational difficulties mentioned in Section 8.5 of Chapter 8 and to the complex issues involving the satisfaction of the wider goals and objectives of Brazilian society. As a developing country, Brazil faces serious capital limitations and the associated complexities in selecting the most appropriate projects that require public capital.

In Chapter 8, it was stressed that the effectiveness of the planning framework developed here depends on the results of its practical implementation by Brazilian planners. Basically, for this planning framework to be effective in incorporating the goals and objectives of the wider community, it needs to be backed by the policy-maker(s) in an interactive way, and to be responsive to local problems and concerns. This study has shown that the framework could support decision making in the "Cerrado" in a more-or-less effective way depending on the availability and quality of data and information.

Thus, this chapter discusses the planning framework developed here and the concept of information systems; its incorporation into regional decision making; and what needs to be done to make this expanded framework operational.

9.1 The Planning Framework and the Concept of Information Systems

Figure 4.1 shows the component interrelationships of the planning framework developed here. It was designed in accordance with the primary objectives of this study.

However, a secondary objective of this study was to investigate the possibility of incorporating this planning framework, with its models, into a decision support (information) system.

The planning framework developed here relates to farm and regional levels. At the farm level, important agro-economic[1] circumstances that affect farmers' decisions were incorporated in suitable models. At the regional level, social, economic, agronomic, and environmental goals and objectives were incorporated into a multiple criteria decision making model. Data and information generated at the farm level using the CECROPF model were analysed and incorporated with other data and information from the regional level into a multiple objective planning model.

Definitions of what constitute data, information and knowledge can be used to present the concept of information systems. Conceptually, data are symbolic representations of quantities and actions, and are the direct product of counting or measurement. Information combines data from different collection processes and subject matters (e.g. agriculture and the environment). In fact, data are always related to some form of analytical interpretation also within some analytical interpretation[2], Bonnen(1989). By processing, organising, interpreting, and communicating data, information is generated. The value of information derives from its use in decision-making or subject matter evaluation, in the real world. Knowledge refers not just to tested (validated) information which implies some success in accounting for phenomena, or in predicting

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[1]Agro-economic circumstances relate to: farmers' goals, input and output markets, land tenure, agricultural credit, climate, variety and soil characteristics.
[2]Interpretation from little more than formatting of data to modelling complex system or phenomena.

their occurrence, but to something around which a scientific or professional community consensus has formed.

Blackie and Dent(1979) stressed that the concepts behind information systems may be viewed in a decision-making context. An information system encompasses all the processes required to produce information relevant to decision-making, and its simplest representation can be viewed as consisting of three basic elements:

INPUT --->	PROCESSOR --->	OUTPUT
Raw data	Process	Information

The complexity of a information system depends on the elements and interrelations incorporated within it. An expanded information system concept is presented below.

9.2 Incorporation of the Planning Framework into Regional Policy Making

The incorporation of the planning framework developed here into a regional policy making aid, represents an evolutionary effort of synthesis of data and information on "Cerrado" agriculture. This involves data and information from different Brazilian institutions and the crucial participation from policy maker(s) as shown in Figure 9.1. One way in which processed data can be organised into useful decision support information, is by developing a viable expert system. This new component to be incorporated with the planning framework into the proposed information system, involves careful attention to well-defined objectives, especially with regard to each project's requirement of knowledge acquisition. Moreover, the number of fielded or operational agricultural expert systems remain low, Jones(1989).

The issue is what needs be done to make the conceptual information system described in Figure 9.1 operational ?

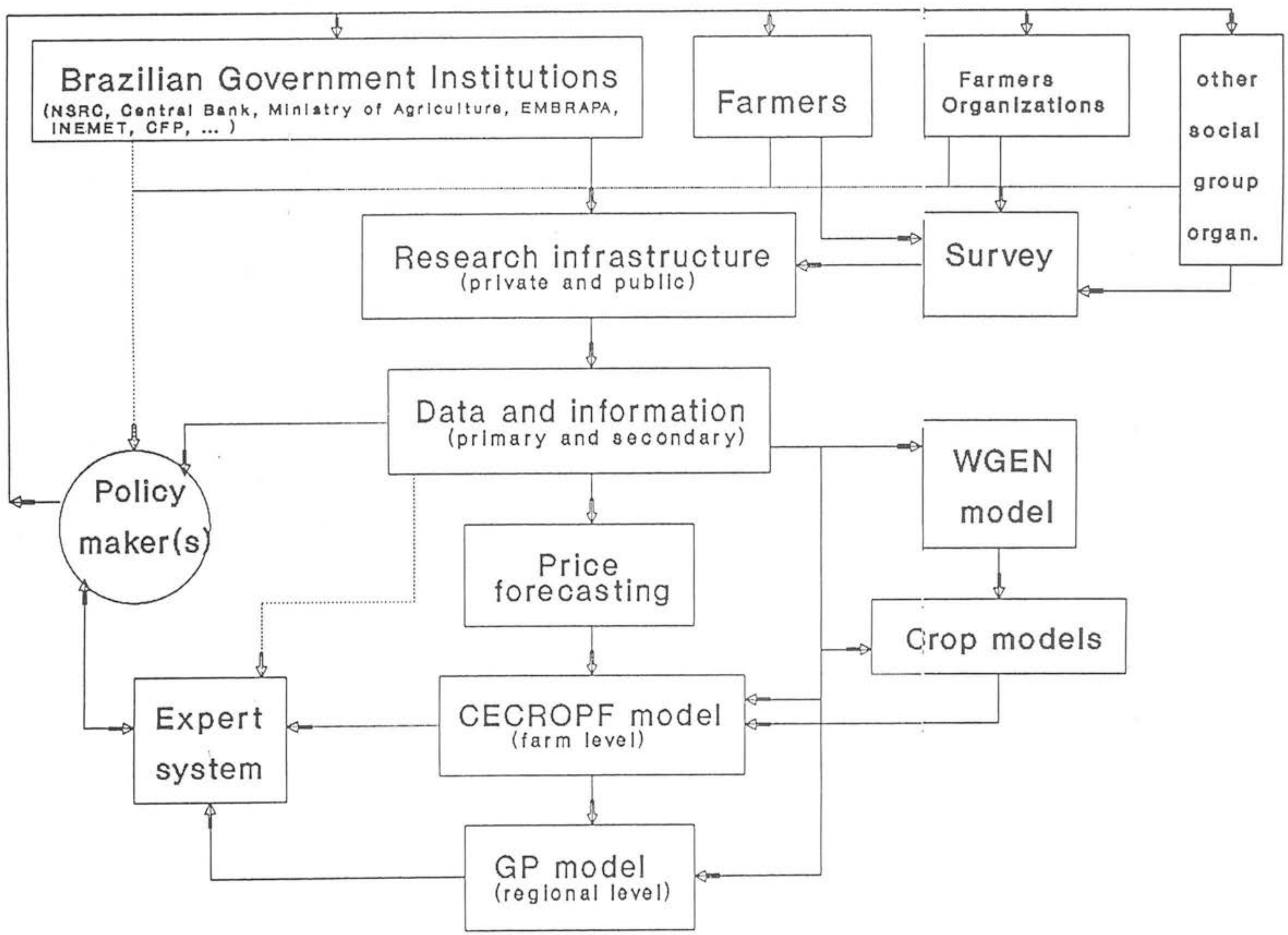

Figure 9.1: Applying the Planning Framework to an Information System

9.3 What Needs to be Done to Make this Expanded Framework Operational

Experimental programmes that have already been established by Brazilian institutions such as EMBRAPA, could incorporate specific experiments to support the validation of crop models for local conditions. This may be justified by the fact that validated crop models offer great potential to evaluate alternative technological packages and agricultural planning issues. Furthermore, surveys designed to explore implicit assumptions present within the CECROPF model should be instigated, with a view to improving the representation and understanding of famer attitudes and behaviour. The assumptions involving discretionary consumption of the farm family and private capital requirements to start the farm business are examples of data that might be elicited in greater detail. A more detailed knowledge of soil types and productivity would allow better specification of the alternative farm systems, for both farm and regional level analyses.

In an effort to generate data and information for decision support, Brazilian research infrastructure should develop and use other tools such as a spatial land-use data base or a Geographical Information System (GIS), illustrated for example in Figure 9.2. The advantage of using decision support system such as an extensive GIS, relates to its capabilities to support ad hoc data analysis as well as decision modelling activities such as those included in Figure 9.1, Harsh(1987).

However, what needs to be done to make this expanded framework (Figure 9.1) operational[3], requires more than

[3]To be operational, such an information system should support political decision-maker(s) in an unstructured or semi-strutured decision situations.

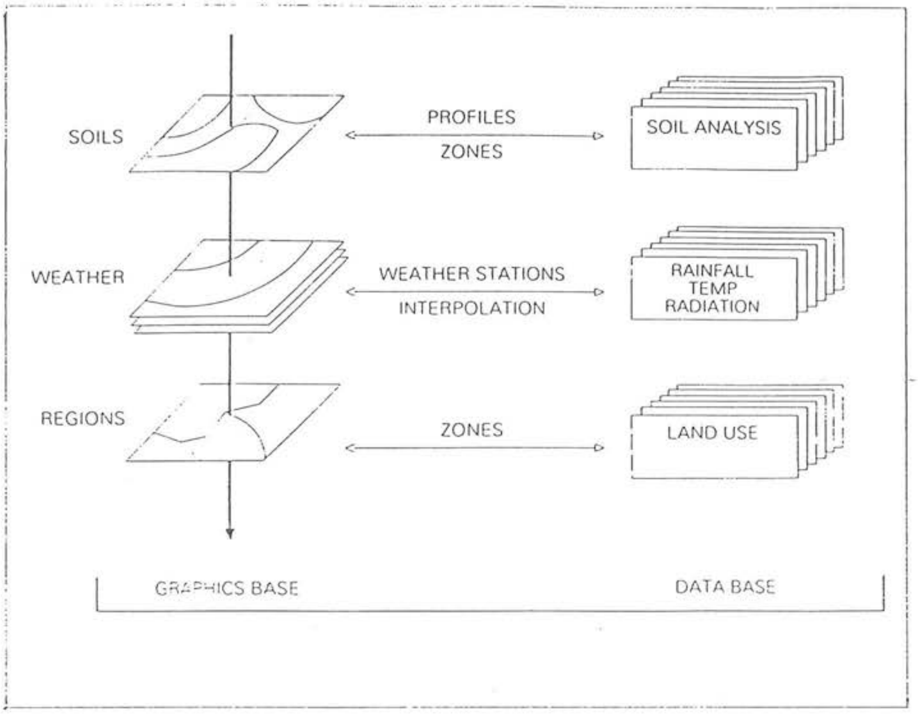

Figure 9.2 Geographical Information System

Source: Thornton and Dent(1990) Using Models to Explore Farming Alternatives.

the development of complementary tools such as a GIS. This requires some development of interfaces between the CECROPF and GP models, the CECROPF and the expert system components; and a great deal of effort to meet the data and information requirements of the several modelling components.

This expanded framework covers a range of fundamental issues involving crop farm development. Nevertheless, during the design stage of model building it was necessary to place boundaries on the system under study. This necessarily lead to the exclusion of farming activities, some of which represent economically significant enterprises within the area under study. Excluded items that should be considered in subsequent developments of the modelling framework include livestock and other enterprises. It should be noted however, that the model presents a significant level of complexity, and care is required in selecting additional items for incorporation into the model.

A difficulty faced within this study was the organisation and manipulation of large quantities of data. As the results of lower level model runs are used as inputs to farm and regional level model runs, a significant time expenditure was required to establish an adequate interface between the various models.

The strengths of this expanded framework refer to the possibility of projecting the landuse of a whole region by using data and information of different sources in an experimental way. Experience in use and application will dictate how satisfactory the framework developed can be in development planning.

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APPENDICES

APPENDIX 01 Statistical Information[1] Relating to the Brazilian Economy

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(1) Permission received from Wicks(1989) to include these data/information.

Table A1.01 - BRAZIL: Indicators of Economic Growth, 1980 - 1988

Year	Gross Domestic product (GNP)	..............Percentage.................. Agriculture	Industry	Commerce
1980	9.1	6.3	7.8	7.7
1981	(-3.1)	6.4	(-6.3)	(-6.7)
1982	1.1	(-2.5)	0.3	0.1
1983	(-2.8)	2.2	(-5.7)	(-5.4)
1984	5.7	3.2	6.0	6.5
1985	8.4	10.1	9.0	8.9
1986	8.0	(-7.9)	12.1	9.9
1987	2.9	14.0	0.2	12.6
1988	(-0.1)	0.1	(-3.2)	N/A

Notes: A. Brazilian population (1988): 144 million.
B. Gross Domestic Product (1988): US$ 287 billion.
C. Monthly minimum wage (February 1988): US$ 63.90.
Source: "Fundacao Getulio Vargas" (FGV)

Table A1.02 - BRAZIL: Major Economic Indicators, 1980 - 1988.

Year	Inflation %	$OTN^{(a)}$ Cz$	$CPI^{(b)}$ %	$FPI^{(c)}$ %
1980	110.3	50.78	86.3	90.9
1981	95.2	95.57	93.5	80.6
1982	99.7	97.80	100.3	95.5
1983	211.0	156.60	178.0	219.2
1984	223.8	215.30	209.1	206.4
1985	224.4	219.40	239.1	253.4
1986	62.4	106.40	59.2	44.9
1987	365.9	522.90	394.6	364.0
1988	933.6	4790.89	993.3	1098.3

(a) OTN - National Treasure Bills (replaced ORTN - National Indexex Treasure Bills).
Effective January 16, 1989 the OTN was abolished, and its value frozen at NCz 6.17.
(b) CPI - Consumer Price Index, city of Rio de Janeiro.
(c) FPI - Food Price Index, city of Rio de Janeiro.
Source: "Fundacao Getulio Vargas" (FGV), and Fundacao Instituto Brasileiro de Geografia e Estatistica (FIBGE).

Table A1.03 - BRAZIL: Balance of Payments and Trade, 1980 - 1988.

Year	Foreign Exchange Reserves	Total Foreign Debt	........................US$ Billions.......................... Annual Debt Service	Current Account Deficit	Exports (FOB)	Imports (FOB)	Trade Balance
1980	6.9	53.8	13.0	12.9*	20.1	22.9	2.8*
1981	7.5	61.4	16.7	11.7*	23.3	22.1	1.2
1982	7.0	82.0	14.6	16.3*	20.2	19.4	0.8
1983	4.6	91.6	19.8	6.1*	21.9	15.4	6.5
1984	11.5	102.0	N/A	0.5*	27.0	13.9	13.1
1985	10.5	105.1	N/A	0.3*	25.6	13.2	12.4
1986	4.6	110.6	9.3	5.3*	22.3	14.0	8.3
1987	4.4	121.0	8.8	1.4	26.2	15.0	11.2
1988	6.0	117.4	10.2	4.0	33.8	14.7	19.1

* Negative values.
Source: Banco Central do Brasil.

Table A1.04 - BRAZIL: Summary of Agricultural Trade, 1980 - 1988.

Year	Agricultural Exports Total	To USA	USA %	Agricultural Imports Total	From USA	USA %
1980	10,788	2,019	19	2,348	680	29
1981	11,559	1,905	16	2,071	710	34
1982	9,744	1,496	15	1,804	526	29
1983	11,068	1,656	15	1,486	479	32
1984	13,243	2,110	16	1,577	504	32
1985	11,731	2,333	20	1,433	470	33
1986	9,930	1,833	18	2,625	566	22
1987	11,201	1,842	16	1,682	292	17
1988	13,100	2,155	16	1,200	146	12

Source: Carteira do Comercio Exterior (CACEX), Banco do Brasil (BB).
CIEF (Ministry of Finance) and
USDA Census Data.

Table A1.05 - BRAZIL: Export Earnings from Key Agricultural Products, 1984 - 1988.

	................US$ Millions................				
Commodities	1884	1985	1986	1987	1988
Soyabeans					
beans	454	764	243	570	728
meal	1,460	1,177	1,180	1,450	2,024
oil, crude	557	331	71	172	45
oil, refined	94	273	67	132	249
Sub-total	2,565	2,545	1,561	2,324	3,046
Coffee					
beans	2,564	2,338	2,063	1,959	1,998
soluble	292	269	297	226	232
Sub-total	2,856	2,607	2,360	2,185	2,230
Cocoa					
beans	249	360	273	266	216
cake	46	31	23	33	32
butter	168	203	199	184	171
liquor	193	177	124	99	95
Sub-total	656	771	619	582	514
Sugar					
raw	326	166	138	134	167
crystal	48	33	46	31	16
refined	213	165	184	160	162
Sub-total	587	364	368	325	345
Meat					
beef, fresh	214	264	165	208	374
beef, proceed	307	262	221	223	259
equine	18	15	8	5	5
poltry	263	244	224	216	235
Sub-total	802	785	618	652	873
Orange juice	1,415	753	636	832	1,144
Tobacco	449	438	396	405	511
Total	9,330	8,263	6,558	7,305	8,663

Source: Wicks(1989) Agricultural Situation 1988. USDA, Foreign Agricultural Service, Brasilia, Brazil, (pg 15).

Table A1.06 - BRAZIL: Value and Volume of Selected Agricultural Products Exports, 1984 - 1988.

Agricultural Products	1984 US$ 1,000	1984 (MT)	1985 US$ 1,000	1985 (MT)	1986 US$ 1,000	1986 (MT)	1987 US$ 1,000	1987 (MT)	1988[(a)] US$ 1,000	1988[(a)] (MT)
Carnauba wax	10,536	10,010	12,697	9,423	17,285	10,836	19,451	11,656	22,007	11,106
Castor oil, refined	66,081	62,686	57,359	95,033	50,052	95,577	59,029	80,660	48,977	53,957
Cocoa, beans	249,122	107,289	360,614	171,609	272,834	134,474	265,587	143,482	190,187	116,940
Cocoa, butter	167,989	35,843	203,390	42,614	198,761	43,578	184,082	42,708	157,946	42,418
Cocoa, cake	45,964	34,396	30,880	36,356	22,563	33,565	33,210	44,318	29,597	41,280
Cocoa, liquor	194,919	67,358	180,818	67,286	124,178	50,565	98,960	42,178	88,356	41,830
Coffee, beans	2,581,850	1,029,730	2,369,178	1,014,171	2,062,741	539,899	1,959,196	987,609	1,170,310	513,919
Coffee, soluble	268,457	46,310	263,293	52,743	296,756	46,206	209,814	36,113	124,284	23,146
Cotton, raw	42,184	32,793	76,754	101,826	16,849	36,598	160,179	173,940	30,971	33,997
Cotton, fabric	195,191	56,231	138,212	40,368	131,087	35,345	150,739	39,041	135,848	34,927
Cotton, yarn	235,031	87,913	156,295	65,101	114,681	47,785	221,603	73,128	183,062	57,371
Cottonseed/oil, refined	71,478	92,844	71,769	177,998	30,935	92,331	29,266	82,510	40,437	89,610
Essential oils	32,504	26,541	32,244	22,791	27,537	29,323	51,039	47,983	46,500	42,385
Fruits, fresh	N/A	N/A	181,923	N/A	184,681	N/A	164,973	N/A	173,362	N/A
Hides and skins	124,519	31,190	139,199	35,503	108,665	22,244	183,392	33,687	329,769	61,133
Juice, orange	1,425,424	911,002	748,925	484,782	635,987	751,834	830,670	755,032	1,014,613	588,567
Meat, beef	214,528	115,397	263,548	140,662	221,112	80,150	207,665	65,557	358,670	160,624
Meat, equine	18,473	15,393	15,182	14,487	7,832	7,238	3,885	3,570	4,362	3,629
Meat, extract	21,522	3,448	19,613	3,175	17,025	2,686	12,205	2,146	23,709	2,768
Meat, poultry	260,831	276,655	243,799	278,655	220,306	224,652	227,080	215,693	223,702	219,460
Meat, processed	307,406	141,569	262,095	130,274	185,248	107,800	223,111	89,245	246,784	124,265
Molasses	22,239	371,719	10,174	218,091	21,211	374,340	26,514	451,677	19,896	318,665
Nuts, Brazil	24,330	19,664	25,178	24,929	22,018	19,900	29,133	20,220	24,304	17,174
Nuts, cashew	66,230	14,819	102,975	24,888	108,020	21,467	87,791	15,223	102,848	21,405
Peanut oil, crude	12,813	13,755	45,903	56,430	3,863	7,176	9,699	22,353	3,181	6,473
Pepper	74,201	37,430	79,698	25,664	92,399	21,996	124,290	27,227	49,146	18,254
Sisal, cordage	65,258	118,259	50,599	105,235	48,721	82,221	40,354	67,307	54,388	74,519
Sisal, raw	29,564	82,564	26,746	82,840	23,160	66,762	21,157	60,095	25,557	64,081
Soyabeans	454,116	1,561,110	762,683	3,495,316	243,218	1,200,151	570,277	3,023,651	724,176	2,583,757
Soyabean meal	1,463,675	7,612,584	1,174,857	8,598,710	1,180,579	6,542,234	1,449,966	7,802,299	1,891,809	7,669,425
Soyabean oil, crude	557,178	803,028	331,393	521,276	71,371	215,115	172,341	574,228	42,928	104,170
Soyabean oil, refined	94,174	125,926	271,124	435,155	66,743	168,206	131,951	414,352	235,607	542,664
Sugar, crystal	47,692	302,788	33,421	308,353	46,226	303,937	30,583	192,703	16,211	92,322
Sugar, raw	313,960	1,500,806	166,284	1033,833	137,999	873,843	134,399	907,860	114,021	665,804
Sugar, refined	212,573	1,211,765	168,250	1,167,204	183,656	1,153,959	159,630	1,094,827	161,338	776,342
Tea, herbal	15,702	20,146	14,007	22,149	16,888	12,975	19,562	17,658	32,191	27,511
Tobacco, unmanufactured	449,509	161,127	437,427	169,811	395,944	149,078	415,496	1733,684	504,057	191,845
Woods, wood products	330,346	N/A	302,977	788,102	309,685	760,787	399,845	806,625	463,108	1,175,674
Wool, raw	48,996	12,280	35,752	9,248	35,746	13,405	50,578	14,000	64,999	12,303
Total	10,816,565	17,154,368	9,867,23	20,072,0915	7,954,562	14,380,238	9,178,707	18,656,245	9,173,218	16,625,720

(MT) Metric ton.
(a) January to November period (only).
Source: Carteira do Comercio Exterior (CACEX), Banco do Brasil (BB).

Table A1.07 - BRAZIL: Area Harvested and Production of Selected Commodities, 1984 - 1988.

Commodities	1884 Area (ha)	1884 Prod. (10^3 MT)	1985 Area (ha)	1985 Prod. (10^3 MT)	1986 Area (ha)	1986 Prod. (10^3 MT)	1987 Area (ha)	1987 Prod. (10^3 MT)	1988 Area (ha)	1988 Prod. (10^3 MT)
Banana[(a)]	400	5,100	440	5,438	430	5,480	448	5,592	460	5,596
Beans, dry	5,319	2,615	5,317	2,250	5,484	2,210	5,221	2,016	5,913	2,911
Castorbeans	410	263	495	415	460	261	263	107	274	N/A
Cocoa beans[(b)]	606	309	606	415	630	372	630	356	630	395
Coffee[(c)]	3,030	1,620	3,045	1,980	3,045	834	3,450	2,280	3450	1,500
Corn	12,700	21,000	12,00	22,000	12,500	21,000	13,500	26,500	12,700	24,000
Cotton	1,960	658	2,420	965	2,290	780	2,165	605	2,497	840
Garlic	12	43	11	44	15	63	18	76	14	56
Grapes	60	600	58	718	58	590	59	557	58	762
Jute and Malva	75	71	73	62	65	64	65	66	61	69
Manioc or cassava	1,770	20,000	1,860	23,000	2,050	25,500	1,934	23,500	1,744	21,513
Nuts, Brazil[(d)]	*	25	*	30	*	25	*	22	*	24
Nuts, Cashew[(e)]	152	21	160	25	160	22	170	22	170	28
Onions	68	710	57	637	63	635	75	857	70	753
Oranges[(f)]	632	10,309	701	11,715	718	11,015	749	10,895	800	10,486
Peanut, in-shell	150	245	190	337	161	216	143	196	100	170
Pepper	20	18	19	18	20	22	21	46	23	58
Potatoes	175	2,220	157	1,990	160	1,835	177	2,343	173	2,298
Pineapples[(g)]	32	638	36	762	40	840	45	957	46	1,007
Rice, paddy	5,350	9,270	4,750	9,025	5,590	10,374	5,979	10,419	5960	11,800
Sisal	310	186	333	290	322	246	296	191	301	199
Sorghum	160	260	165	330	198	370	239	453	196	322
Soyabeans	9,421	15,541	10,153	18,278	9,450	14,100	9,270	17,300	10,516	17,800
Sugarcane[(h)]	3,655	9,324	3,915	8,270	3,950	8,650	4,310	8,457	4,130	8,500
Tobacco	276	401	268	411	266	386	276	410	272	419
Tomatoes	50	1,747	54	1,930	52	1,840	58	2,043	61	2,259
Wheat	1,900	1,900	2,800	4,300	3,897	5,600	3,475	6,100	3,450	5,500

(ha) (hectares).

(10^3 MT) (1,000 metric tons).

(*) Not available.

(a) Assumes 92 bunches of bananas per ton.

(b) Production refers to the crop harvested in the international cocoa marketing year beginning in October of the year indicated. Area is for harvested during calendar year indicated.

(c) In 1988, coffee statistics in billion of trees and production in million of 60 kilogram sacks were as follows: 4.0 billion trees and 25 million sacks.

(d) Green weight.

(e) Shelled.

(f) Production of concentrated orange juice (FCOJ) from the citrus crop is as follows (in 1,000 metric tons): 1984: 784.0 1985: 875.0 1986: 603.0 1987: 710.0 1988: 690.

(g) Million fruits.

(h) The sugarcane production statistics is in raw value. Area harvested for cane in season beginning June 1 of year indicated.

Source: Wicks(1989) Agricultural Situation 1988. USDA, Foreign Agricultural Service, Brasilia, Brazil, (pg 29-31).

Table A1.08 - BRAZIL: Production of Animal Products, 1980 - 1988.

Year	Beef and veal	Pork	Total	Milk	Eggs (Mil. units)
	........................1,000 Metric Tons			....	
1980	2,150	1,000	1,326	10,2600	9,6
1981	2,250	980	1,491	10,500	10,2
1982	2,400	970	1,596	10,100	10,2
1983	2,400	950	1,580	10,700	10,0
1984	2,300	567	1,398	10,800	9,5
1985	2,400	600	1,530	10,400	11,0
1986	1,900	850	1,620	9,800	13,0
1987	2,250	1,200	1,800	11,000	15,4
1988	2,250	1,050	1,900	11,500	15,9

Source: Wicks(1989) Agricultural Situation 1988. USDA, Foreign Agricultural Service, Brasilia, Brazil (pg 32)

Table A1.09 - BRAZIL: Tractor Production, 1975 - 1988.

Year	Four wheel types	Caterpiller types	Micro tractors	Motorized Cultivators	Total
1975	57,041	3,200	2,164	3,166	65,571
1976	63,161	3,850	2,149	2,535	71,695
1977	50,390	2,867	2,391	2,989	58,637
1978	46,387	2,996	2,281	3,270	54,934
1979	52902	3,202	2,345	6,062	64,511
1980	58,812	4,285	2,520	6,896	72,513
1981	39,341	3,133	*	4,548	47,022
1982	30,323	1,899	*	5,364	37,586
1983	22,612	751	*	3,213	26,576
1984	43,914	1,762	*	3,300	48,976
1985	45,842	1,348	*	2,595	49,785
1986	51,560	2,409	*	7,096	61,065
1987	47,753	2,677	*	4,313	54,743
1988	39,958	2,818		2,026	44,802

Source: "Associacao Nacional dos Fabricantes de Veiculos Automotores (ANFAVEA).

Table A1.10 - BRAZIL: Pesticides: Imports/Exports - Domestic Production - Consumption, 1975 - 1988.

Year	Imports	Less Exports[b]	Production	Net Total	Inseticides	Fungicides	Herbicides	Total
	....			1,000 Metric Tons	....	......Aparent Consumption[a].....		
1975	51.9		26.5	78.4	41.8	14.2	22.4	78.4
1976	50.8		18.6	69.4	28.5	16.6	24.3	69.4
1977	52.1		26.2	78.3	33.8	24.6	19.9	78.3
1978	47.9		40.6	88.5	42.7	22.9	22.9	88.5
1979	42.1		42.3	84.4	38.9	25.4	20.1	84.4
1980	40.8		56.2	97.0	32.2	36.5	28.3	97.0
1981	23.5		60.5	84.0	22.0	32.0	30.0	84.0
1982	15.5		52.2	67.7	15.4	24.7	27.6	67.7
1983	10.8		55.7	66.5	12.7	25.1	28.7	66.5
1984	14.0	16.0	57.2	55.2	17.0	18.2	20.0	55.2
1985	13.1	19.0	66.0	50.1	17.8	15.0	17.3	50.1
1986	22.3				22.6	23.1	22.1	67.8
1987	15.6	19.1	66.2	62.7	21.1	20.1	21.5	62.8
1988[c]								

[a] Apparent consumption equal to domestic production plus imports les exports. No year stock data available.

[b] Exports during years 1975 to 1983 were not significant. Included in "Apparent Consumption" data.

[c] Not yet available.

Source: Wicks(1989) Agricultural Situation 1988. USDA, Foreign Agricultural Service, Brasilia, Brazil (pg 40).

Table A1.11 - BRAZIL: Fertilizer: Importation, Production and Consumption, 1980 -1988.

	(1,000 Metric Tons - Nutrient Basis)															
	Nitrogen (N)				Phosphate (P_2O_5)				Potash (K_2O)				N P K			
Year	Import	Production	Export	Consumpt.	Import	Production	Export	Consumpt.	Import	Production	Export	Consumpt.	Import	Production	Export	Consumpt.
1980	503	403		906	227	1,626		1,853	1,307			1,307	2,029	2,029		4,066
1981	319	343		662	136	1,078		1215	762			762	1,422	1,422		2,639
1982	244	400		644	72	1,062	35	1,099	876			876	1,462	1,462	35	2,619
1983	102	535	86	551		983	63	920	728			728	1,518	1,518	149	2,199
1984	153	670	18	805	69	1,412	9	1,472	1,076			1,076	2,082	2,082	27	3,353
1985	130	709	3	836	31	1,265	7	1,289	1,053			1,053	1,974	1,974	10	3,178
1986	276	712		988	146	1,416		1,562	1,280		10	1,290	2,138	2,138		3,840
1987	217	746		963	172	1,393		1,565	1,218			1,218	2,139	2,139		3,746
1988	172	705		877	103	1,356		1,459	1,312	56		1,368	2,117	2,117		3,704

Source: Sindicato da Industria de Adubos e corretivos Agricolas do Estado de Sao Paulo.

Appendix 2 Procedures for Farm Product Price Forecasting

A2.1 Introduction

Agricultural product prices in Brazil are characterized by fluctuations resulting from climatic variations, high inflation indices and from government interventions in the market.

This appendix presents the forecasting procedures applied to generate monthly product (rice, maize, wheat and soybean) prices from the year 1987 to 2001. First, a short description of the historical data is presented. Secondly, the choice of an appropriate time series[1] analysis approach and its application for analysing these is discussed. Finally the following are presented: the price forecasting models selected to generate monthly product prices; a description of the forecasted product prices to be incorporated in the CECROPF model; and a brief discussion about the effectiveness of the adopted forecasting approach.

A2.2 Historical Product (Rice, Maize, Wheat and Soybean) Price Data

The series analysed are rice, maize, wheat and soybean prices as shown in Tables A2.01 to A2.04. These are product price (expressed per 60 kilograms of product

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[1]A time series is a collection of observations on values of a variable obtained at regular time intervals made sequentially, Cooke(1985).

Table A2.01: Average Monthly Rice Prices(1) at the Farm Level Goias State - Period 1969-1988

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1969	0.72	0.66	0.54	0.45	0.44	0.44	0.45	0.49	0.58	0.60	0.62	0.58
1970	0.52	0.48	0.42	0.40	0.40	0.44	0.45	0.48	0.47	0.48	0.47	0.52
1971	0.59	0.62	0.66	0.59	0.63	0.70	0.71	0.75	0.78	0.82	0.83	0.85
1972	0.79	0.74	0.68	0.59	0.58	0.60	0.62	0.64	0.67	0.68	0.71	0.71
1973	0.69	0.66	0.61	0.58	0.60	0.62	0.61	0.63	0.68	0.72	0.77	0.74
1974	0.73	0.71	0.73	0.79	0.88	0.88	0.88	0.81	0.87	0.96	0.97	1.03
1975	1.16	1.10	1.00	0.95	0.96	0.99	0.98	0.96	1.06	1.02	0.98	0.98
1976	0.96	0.90	0.75	0.66	0.58	0.58	0.58	0.59	0.60	0.60	0.58	0.57
1977	0.57	0.55	0.56	0.61	0.65	0.68	0.63	0.64	0.64	0.65	0.67	0.69
1978	0.72	0.72	0.70	0.69	0.73	0.78	0.80	0.79	0.80	0.83	0.85	0.92
1979	0.95	0.92	0.89	0.82	0.82	0.86	0.89	0.94	1.03	1.10	1.19	1.32
1980	1.36	1.10	0.97	0.91	0.94	1.05	1.05	1.12	1.05	1.05	1.14	1.13
1981	1.02	0.95	0.94	0.97	0.97	0.94	0.93	0.95	0.99	1.06	1.18	1.27
1982	1.34	1.31	1.16	1.07	1.03	1.07	1.02	1.11	1.13	1.07	1.09	1.17
1983	1.24	1.19	1.04	1.00	1.01	1.09	1.28	1.46	1.57	1.59	1.51	1.48
1984	1.41	1.35	1.23	1.21	1.20	1.12	1.07	1.06	1.07	1.13	1.22	1.42
1985	1.36	1.30	1.21	1.33	1.30	1.29	1.29	1.44	1.65	1.75	1.70	1.91
1986	1.89	1.73	1.40	1.27	1.29	1.33	1.33	1.36	1.38	1.36	1.38	1.45
1987(2)	1.49	1.45	0.88	0.80	0.73	0.71	0.69	0.76	0.80	0.90	0.94	0.96
1988(2)	0.95	0.99	0.99	1.05	1.01	1.08	1.15					

(1)Prices are expressed in terms of the OTN (National Treasury Bills) index per bag (60 kilogram unit).

(2)The 1987 and 1988 observations are used for the purpose of model validation.

Source: "Fundacao Getulio Vargas - FGV" - Rio de Janeiro - RJ - BRAZIL.

Table A2.02: Average Monthly Soybean Prices(1) at the Farm Level Goias State - Period 1975-1988

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1975	0.74	0.77	0.70	0.63	0.60	0.61	0.63	0.70	0.66	0.66	0.63	0.63
1976	0.61	0.61	0.59	0.55	0.53	0.60	0.65	0.65	0.69	0.68	0.67	0.65
1977	0.72	0.72	0.76	0.88	1.01	0.96	0.78	0.79	0.70	0.71	0.71	0.69
1978	0.63	0.63	0.62	0.65	0.69	0.75	0.72	0.71	0.71	0.70	0.71	0.72
1979	0.77	0.80	0.77	0.76	0.76	0.78	0.76	0.80	1.04	1.02	1.04	1.03
1980	1.01	0.98	0.91	0.88	0.82	0.83	0.86	0.90	0.91	1.06	1.02	1.08
1981	1.14	1.11	0.99	0.94	0.94	0.96	0.91	0.96	0.92	0.83	0.79	0.77
1982	0.81	0.88	1.04	1.02	0.97	1.00	0.96	0.89	0.85	0.81	0.76	0.81
1983	0.85	0.86	0.89	0.94	0.95	0.89	1.12	1.41	1.68	2.13	2.20	2.10
1984	2.08	1.85	1.74	1.72	1.65	1.68	1.54	1.38	1.33	1.34	1.38	1.42
1985	1.42	1.45	1.34	1.32	1.17	1.08	1.05	1.06	1.19	1.24	1.43	1.30
1986	1.22	1.19	1.17	1.17	1.17	1.17	1.17	1.18	1.18	1.18	1.20	1.21
1987(2)	1.21	1.22	0.82	0.76	0.87	0.92	0.91	1.02	1.34	1.36	1.38	1.36
1988(2)	1.32	1.45	1.44	1.39	1.30	1.74	1.90					

(1)Prices are expressed in terms of the OTN index per bag.

(2)The 1987 and 1988 observations are used for the purpose of model validation.

Source: "Fundacao Getulio Vargas - FGV" - Rio de Janeiro - RJ - BRAZIL.

Table A3 03: Average Monthly Maize Prices(1) at the Farm Level Goias State - Period 1969-1988

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1969	0.19	0.18	0.18	0.18	0.17	0.17	0.17	0.18	0.20	0.23	0.24	0.23
1970	0.27	0.25	0.24	0.23	0.20	0.20	0.19	0.19	0.19	0.19	0.20	0.22
1971	0.24	0.22	0.23	0.23	0.23	0.22	0.23	0.22	0.22	0.24	0.24	0.24
1972	0.27	0.30	0.30	0.29	0.29	0.30	0.30	0.30	0.30	0.28	0.29	0.33
1973	0.34	0.34	0.34	0.34	0.34	0.33	0.32	0.34	0.37	0.37	0.41	0.41
1974	0.38	0.38	0.36	0.37	0.37	0.35	0.33	0.33	0.32	0.31	0.32	0.36
1975	0.37	0.35	0.36	0.35	0.35	0.34	0.33	0.36	0.38	0.42	0.41	0.42
1976	0.43	0.45	0.44	0.43	0.42	0.40	0.41	0.39	0.38	0.39	0.38	0.37
1977	0.36	0.35	0.35	0.34	0.34	0.32	0.31	0.30	0.29	0.31	0.33	0.33
1978	0.35	0.35	0.35	0.36	0.36	0.38	0.37	0.35	0.36	0.38	0.41	0.46
1979	0.53	0.54	0.50	0.45	0.42	0.42	0.42	0.46	0.47	0.49	0.49	0.53
1980	0.56	0.54	0.53	0.49	0.49	0.50	0.52	0.60	0.58	0.66	0.85	0.98
1981	1.06	1.04	0.99	0.90	0.77	0.66	0.58	0.55	0.54	0.54	0.61	0.59
1982	0.58	0.58	0.58	0.57	0.55	0.54	0.50	0.48	0.49	0.47	0.46	0.49
1983	0.49	0.53	0.55	0.54	0.52	0.51	0.55	0.63	0.76	1.17	1.24	1.24
1984	1.19	1.16	0.99	0.87	0.78	0.70	0.64	0.61	0.61	0.62	0.66	0.77
1985	0.78	0.74	0.76	0.78	0.76	0.70	0.65	0.64	0.65	0.67	0.75	0.85
1986	1.02	0.95	0.80	0.80	0.78	0.78	0.77	0.76	0.76	0.78	0.82	0.87
1987(2)	0.91	0.93	0.55	0.50	0.48	0.45	0.42	0.44	0.45	0.48	0.54	0.61
1988(2)	0.76	0.77	0.75	0.68	0.67	0.69	0.70					

(1)Prices are expressed in terms of the OTN index per bag.

(2)The 1987 and 1988 observations are used for the purpose of model validation.

Source: "Fundacao Getulio Vargas - FGV" - Rio de Janeiro - RJ - BRAZIL.

Table A2.04: Average Monthly Wheat Prices(1) at the Farm Level Goias State - Period 1977-1988

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977	0.70	0.68	0.67	0.98	0.95	0.92	0.89	0.87	0.85	0.84	0.83	0.81
1978	0.80	0.78	0.76	0.97	0.95	0.92	0.89	0.87	0.84	0.82	0.80	0.78
1979	0.76	0.75	0.73	0.92	0.89	0.86	0.83	0.81	0.79	0.76	0.72	0.69
1980	0.66	0.64	0.61	1.30	1.25	1.21	1.17	1.14	1.10	1.07	1.04	1.01
1981	0.96	0.92	0.86	1.95	1.84	1.73	1.64	1.54	1.46	1.38	1.31	1.24
1982	1.18	1.12	1.07	1.45	1.44	1.44	1.44	1.43	1.42	1.42	1.42	1.43
1983	1.34	1.26	1.18	1.30	1.42	1.42	1.32	1.50	1.52	1.52	1.59	1.59
1984	1.58	1.44	1.28	1.76	1.92	1.91	1.92	1.94	1.73	1.73	1.73	1.76
1985	1.79	1.84	1.67	1.93	1.93	1.94	1.93	1.94	1.94	1.99	1.99	1.96
1986	1.98	2.02	1.77	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88
1987(2)	1.88	1.88	1.10	1.30	1.20	1.22	1.03	1.00	1.35	1.35	1.35	1.35
1988(2)	1.18	1.01	0.86									

(1)Prices are expressed in terms of the OTN index per bag.

(2)The 1987 and 1988 observations are used for the purpose of model validation.

Source: "Fundacao Getulio Vargas - FGV" - Rio de Janeiro - RJ - BRAZIL.

weight) data at the farm level, at the end of the month, in the Paracatu region, collected by the Fundacao Getulio Vargas (FGV) from farms and cooperatives. In consequence of the Brazilian inflationary economy in the last two decades the National Treasury Bills (OTN) index has been used in planning processes. This is the reason why the product price series mentioned above are in OTN.

The OTN index is better understood as a planning element by analysing the ratio US$/OTN, Tables A2.05. Also, the trends of the product price series shown in the Figure A2.1 are comprehensible.

Dent and Blackie(1979) have stressed that the effects of events which do not appear in the historical series, along with the effects of different sequences of events, cannot be readily explored. Also, the price series cannot be long enough to avoid sampling errors. However, the aim here is not to take issue with the theoretical arguments involving price forecasting. It is assumed that the product price series are able to produce acceptable price forecasting models.

A2.2.1 Long term trends

Three of the price series exhibit a general upward trend over time. The variability of wheat prices is different from the others mentioned above, due to the control of the Brazilian government over wheat marketing. Rice and maize price series are characterized by variabilities related to climatic changes. The soybean price series also depends to an extend on climate changes. However, soybean prices also depend on the international market which is greatly influenced by the production of soybean in the USA(2).

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(2)The largest producer of soybean in the world.

Table A2.05: US Dollars(1) per one Brazilian National Treasure Bill(2) (ORTN or OTN or BTN)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1971	10.20	10.29	10.30	10.30	10.26	10.28	10.42	10.42	10.50	10.65	10.68	10.78
1972	10.88	10.76	10.85	10.92	10.96	11.12	11.26	11.38	11.38	11.38	11.38	11.32
1973	10.27	11.70	11.99	12.11	12.14	12.29	12.38	12.48	12.56	12.64	12.73	12.76
1974	12.95	12.77	12.81	12.87	12.98	12.99	13.08	13.47	13.90	14.27	14.33	14.31
1975	14.33	14.31	14.37	14.38	14.45	14.66	14.69	14.65	14.66	14.71	14.66	14.57
1976	14.60	14.58	14.51	14.03	14.00	14.08	14.26	14.35	14.41	14.56	14.69	14.79
1977	14.74	14.69	14.65	14.61	14.64	14.74	14.82	14.94	15.01	15.01	14.95	14.75
1978	14.80	14.86	14.93	15.03	15.08	15.23	15.40	15.47	15.54	15.68	15.63	15.50
1979	15.41	15.22	15.09	14.98	14.81	14.72	14.95	14.87	14.34	14.22	14.25	11.84
1980	11.19	11.34	11.33	11.35	11.39	11.42	11.45	11.42	11.79	11.30	11.17	11.04
1981	10.96	11.01	11.15	11.10	11.12	11.11	11.15	11.11	11.15	11.13	11.13	11.05
1982	11.10	11.07	11.05	11.08	11.11	11.14	11.13	11.03	11.09	11.14	11.16	11.17
1983	11.07	9.89	8.20	8.20	8.23	8.18	7.97	7.70	7.71	7.53	7.45	7.42
1984	7.40	7.33	7.37	7.38	7.40	7.38	7.31	7.34	7.35	7.29	7.40	7.34
1985	7.29	7.32	7.28	7.24	7.31	7.32	7.37	7.35	7.15	7.12	7.12	7.08
1986	7.27	7.15	7.66	7.66	7.66	7.66	7.66	7.66	7.66	7.66	7.51	7.27
1987	6.77	5.84	8.68	8.76	8.18	7.78	8.16	8.01	8.05	7.95	7.82	7.71
1988	7.60	7.55	7.62	7.59	7.47	7.46	7.34	7.38	7.37	7.16	7.15	7.13
1989	6.83	1.(3)	1.04	1.08	1.07	0.97	0.85	0.84	0.83	0.82	0.81	0.79
1990	0.77											

(1)Official exchange rate.

(2)ORTN: from January 1982 to February 1986; OTN: from March 1986 to January 1989; and BTN: after February 1989.

(3)In February of 1989, the OTN index was changed to BTN index in an appropriate way (1 OTN value was converted to over 6 BTNs).

Source: Banco Central do Brasil and SPL/EMBRAPA - Brasilia,DF.

A2.2.2 Seasonal fluctuations

Visual inspection of the product price series in Figure A2.1 suggests that there is a seasonal pattern in the fluctuations of price in the long term. Such fluctuations arise as a result of droughts or other climatic conditions and government interventions in the product market.

Short term changes to the general seasonal pattern illustrated in Figure A2.1 occur within individual years as a result of the production and supply seasons.

A2.2.3 Price interrelations

The product price series analysed here do not present a strong tendency to follow a similar pattern of change over time (see Figure A2.1). This is discussed below.

A2.3 The Choice of an Appropriate Time Series Analysis Approach

Forecasting techniques have been classified by Farnun and Stanton(1989) in four groups: econometric modelling, time series analysis, expert opinion and other types of data analysis. The econometric modelling approach is useful for expressing the interrelationships between a set of explanatory variables that affect (and are perhaps affected by) the quantity being forecast. Once knowledge of the 'explanatory' variables is available, the analyst or decision maker can use it to compute forecasts. Data of this type were not available for this study. Consequently, time series analysis[3] appeared to be an acceptable approach to the carrying out of forecasts for the prices mentioned above. The premise here is that time-dependent patterns and relationships exist in the

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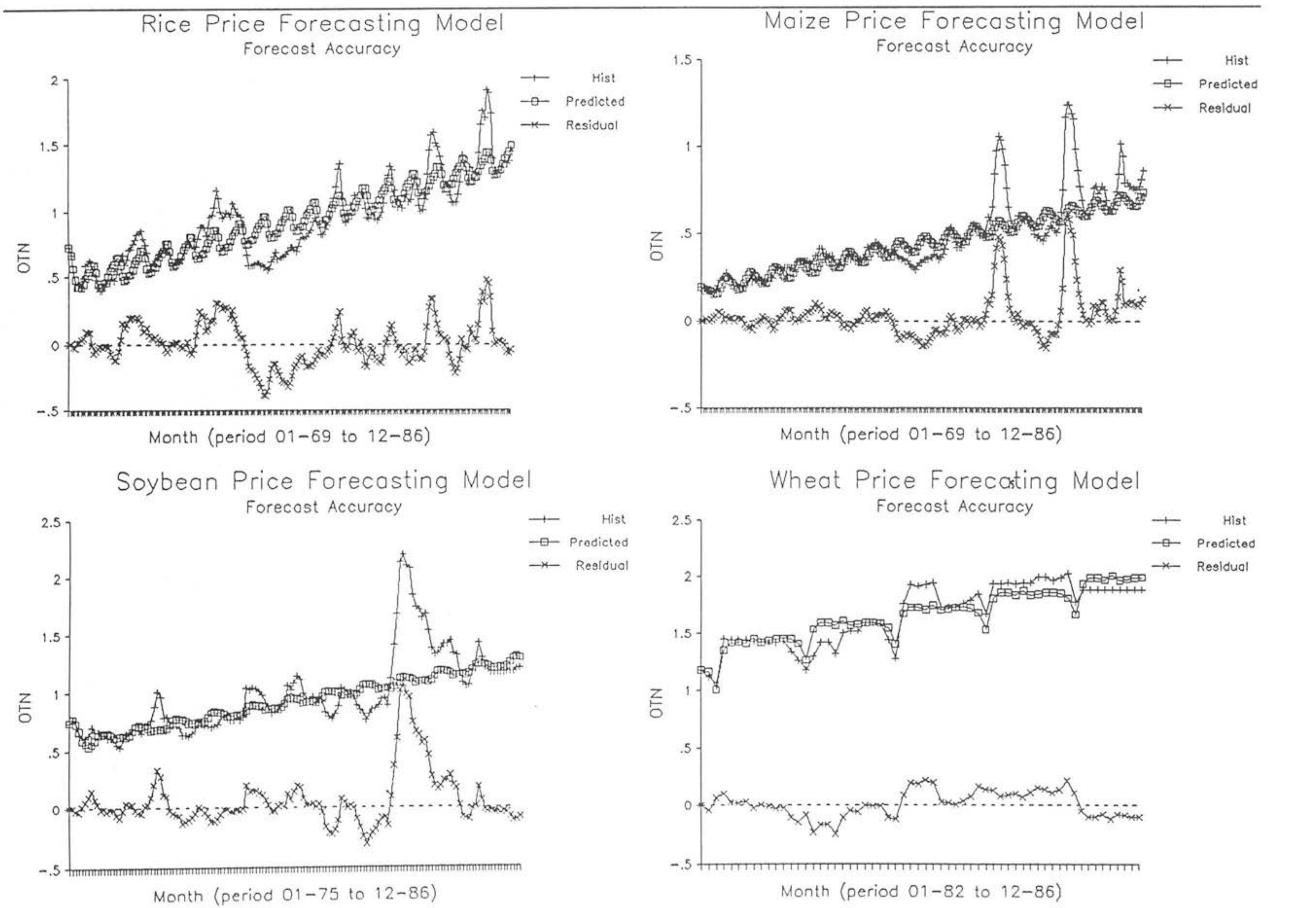
[3]Time series analysis regards movements in a given variable to be solely a function of time, Rogers(1977).

Figure A2.1: Plot of Historical versus Predicted Values for Prices and Corresponding Regression Residuals



product price data and that they are stable enough to allow extrapolation into the future. Of course, this premise presents difficulties in forecasting any price series in Brazil due to the need for government to intervene in the determination of prices in more recent years. However, in the circumstances of this study no other option exists for forecasting the product price series under consideration and the approach was adopted in spite of obvious limitations, well illustrated in Figure A2.2.

Many different techniques for time series analysis have been developed and studied over the years, and many approaches have been suggested for identifying an appropriate time series model[4]. The complexity of time series models depends on the time series components under consideration. Time series models can be classified as follows: models for trend component, models for trend and seasonal components, and models for trend, seasonal and cyclical movement components together, (de Souza 1989, pers. com.).

Cost/benefit considerations are basic in choosing a time series technique. This involves cost-related items (such as data acquisition, data storage and computer time), forecast accuracy and forecast horizon, time units, and data availability. Thus, in this study, the adoption of more complex modelling methodologies was avoided. Some statistical procedures which are incorporated in the Statistical Analysis Systems (SAS) software were used to adjust alternative price series models. Statistical parameter estimates were considered in selecting the most appropriate models for generating product price series for the CECROPF model. This is briefly described below.

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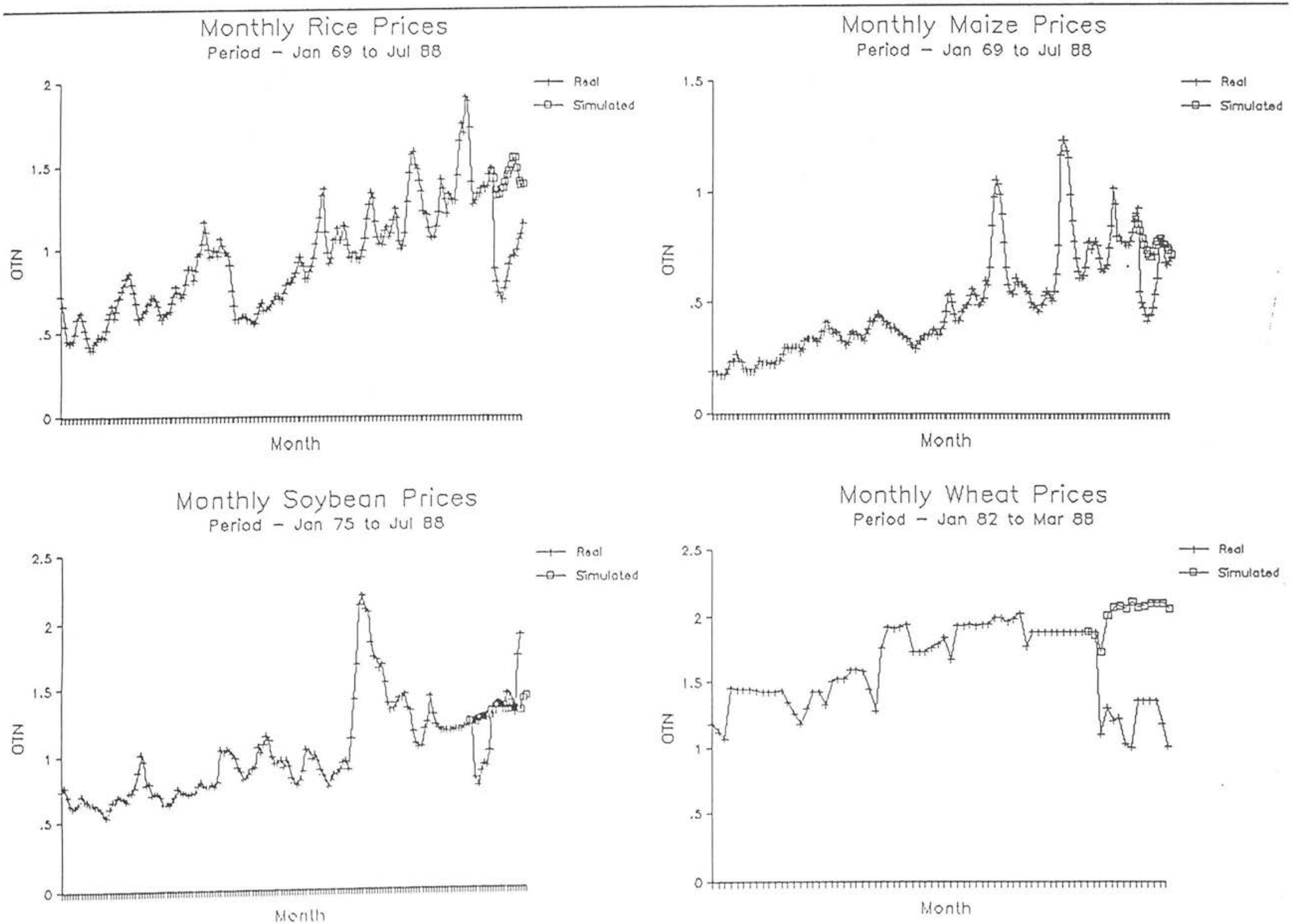
[4]A time series model for forecasting y_t is any mathematical model having only time and past values of y_t as its inputs, Farnum and Stanton(1989).

Figure A2.2: Comparison of Historical and Predicted Values for Prices Corresponding the Period 1987 to 1988.



A2.4 Generation of Product (Rice, Maize, Wheat and Soybean) Price Series

The analysis of the product price series under consideration involved the following:

i. examination of the series graphics (plot of y_t[5] versus t) for trends, seasons, cyclical behaviour and irregular components;

ii. formulation (based on the interpretation of the graphics, (see Figure A2.1)), estimation and diagnostic checking of statistical models;

iii. analysis of the results of the adjusted statistical models; and

iv. selection of the best adjusted statistical models.

A2.4.1 Statistical results of adjusted autoregressive models

Table A2.6 summarizes the results obtained using SAS for the selected models. The presence of autocorrelation in the price series eliminated some of the formulated statistical models. However, all price series are stationary[6] after a first-order differencing.

According to the statistical results presented in the Table A2.6 and in the Figure A2.1, all four time series are well described by autoregressive[7] models with indicator or dummy variables to represent the seasons (months), (de Souza 1989, pers. com.). Autoregressive models were selected after checking for the presence of autocorrelation in the residuals using the Durbin-Watson d test and an examination of the effects of overfitting

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[5]It is the price value variable in time t.

[6]The characteristics of the price series change over time. A non-stationary series can be transformed into a stationary series by using a technique known as differencing, Chatfield(1980).

[7]Regression models using only lagged values (y_{t-1}, y_{t-2},..) of y as predictor variables are called autoregressive models, Cooke(1985).

Table A2.06: Statistical Results of the Autoregressive Models of Rice, Maize, Soybean and Wheat Prices

	Parameter Estimates											
	Rice price model			Maize price model			Soybean price model			Wheat price model		
Equat.	par[1]	standard error	prob > :T	par	standard error	prob > :T	par	standard error	prob > :T	par	standard error	prob > :T
	b_0			b_0			b_0			b_0		
Jan	.0335	.0194	.0866	.0396	.0106	.0002	.0105	.0293	.0005	.2183	.1188	.0726
Feb	-.0053	.0195	.7870	.0237	.0111	.0335	.0765	.0294	.0103	.1831	.1135	.1138
Mar	-.0130	.0192	.4997	.0190	.0105	.0710	.0714	.0284	.0132	.0707	.1093	.5211
Apr	.0391	.0185	.0358	.0235	.0103	.0236	.1055	.0288	.0004	.4566	.0967	.0001
May	.0549	.0170	.0015	.0179	.0102	.0825	.0835	.0286	.0041	.2849	.1179	.0198
Jun	.0570	.0167	.0008	.0183	.0101	.0707	.0943	.0274	.0008	.2383	.1214	.0558
Jul	.0327	.0169	.0547	.0135	.0099	.1711	.0686	.0274	.0136	.2165	.1204	.0788
Aug	.0706	.0170	.0001	.0277	.0098	.0051	.1091	.0272	.0001	.2712	.1177	.0259
Sep	.0698	.0174	.0001	.0218	.0098	.0270	.1104	.0276	.0001	.1962	.1200	.1090
Oct	.0509	.0180	.0052	.0475	.0098	.0001	.1165	.0282	.0001	.2375	.1157	.0459
Nov	.0575	.0183	.0019	.0388	.0101	.0002	.0935	.0290	.0016	.2414	.1155	.0423
Dec	.0878	.0186	.0001	.0443	.0103	.0001	.0796	.0291	.0070	.2299	.1156	.0529
	b_1			b_1			b_1			b_1		
	.0004	.0001	.0003	.0004	.0001	.0001	.0008	.0002	.0004	.0018	.0013	.1630
	c_1			c_1			c_1			c_1		
	1.3110	.0647	.0001	1.1821	.0652	.0001	1.2234	.0807	.0001	.8291	.0876	.0001
	c_2			c_2			c_2			c_2		
	-.0409	.0645	.0001	-.3437	.0612	.0001	-.3860	.0075	.0001			

	Regression diagnostic			
	Rice price model	Maize price model	Soybean price model	Wheat price model
Adjusted R^2	.9969	.9955	.9955	.9985.
Degree of differencing	1	1	1	1
Durbin-Watson test[2]				
d test	1.955	2.150	2.191	1.7347
1^{st} order autocorrelat.	.022	-.078	-.096	.1277

(1)The parameter b_0 varies from month to month.
(2)The Durbin-Watson statistic d is a test for first-order (i.e., lag1) autocorrelation in the regression residuals. It always lies between 0 and 4. Values close to 2 indicate independent error terms. Furthermore, by comparing the r_1 ($r_1 = 1 - d/2$) values to the rule-of-thumb value of $\pm 2 / \sqrt{20} = .45$, there is no positive autocorrelation in the adjusted models, Farnum and Stanton(1989, pg 301).

the model. The mathematical description of the product (rice, maize and soybean) price forecasting models is

$$y_t = b_0 + b_1 t + c_1 y_{t-1} + c_2 y_{t-2} + e_t$$

where $b_0 + b_1 t$ are used to denote the trend component[8], $y_{t-1} + y_{t-2}$ are used to denote the seasonal component and e_t is used to denote the random component. The wheat monthly price forecasting model is similar, but does not include the variable y_{t-2}.

A2.4.2 Forecasted product prices

The adaptative lag models obtained[9] generate one-month forecasts. In order to generate monthly prices of each product for the period 1987 to 2001, four short different SAS programs were written and applied.

Forecasted product prices for the period 1987 and 1988, were used to compare the forecast of the referred time series models with corresponding historical price data. This is briefly discussed below.

A2.4.3 Effectiveness of the adopted forecasting approach

The effectiveness of the price forecasting approach appears to be acceptable for the purpose of this study. However, Figure A2.2 shows that performance of the adjusted price forecasting models is limited in circumstances of continuous government interventions in the economy such as occurred after 1985. A better correspondence is achieved between predicted and historical prices prior to 1985 as shown in Figure A2.1

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(8)Using dummy variables in the statistical model formulation, the values y_{t-1} and y_{t-2} are lagged in twelve months. Where y_{t-1} for a January equation means the January value of the previous year.

(9)The collaboration of EMBRAPA's statisticians (Dr Geraldo de Souza and Raimundo Quindere) was fundamental in the adjustment and application of such models.

Although autoregressive models have been suggested in the literature, long term price forecasting is a difficult modelling task as shown in Figure A2.3, Bhaskar(1978, pg 318).

Figure A2.3: Accuracy of Forecasting Techniques

TIME SERIES TECHNIQUES	TREND	MOVING AVERAGE	EXPONENTIAL SMOOTHING	AUTOREGRESSIVE	BOX JENKINS
SUMMARY	Fits a trend line and then projects this into future	Eliminates affects of seasonal or irregular detail by taking average of last periods	Similar to moving average except that more recent history is given more importance	Here weights are chosen by the model	Combines autoregressive and moving average. This is probably the most accurate of the time series techniques.
ACCURACY					
SHORT TERM 0–3 mths	Fair	Poor to good	Fair – v. good	Very good	Very good to excellent
MEDIUM TERM 3–36 mths	Fair	Poor	Poor to good	Fair to good	Fair to good
LONG TERM OVER 3 yrs	Good	Very poor	Very poor	Poor	Poor

ECONOMETRIC MODELS	SINGLE EQUATION	SIMULTANEOUS EQUATION MODEL
ESTIMATION PROCEDURE	Multiple regression using Ordinary least squares	Model estimated using two stage least squares on Full Information Maximum Likelihood
ACCURACY		
SHORT TERM 0-3 mths	Fair – Very good	Good – Very good
MEDIUM TERM 3-36 mths	Good	Very good to excellent
LONG TERM OVER 3 yrs	Poor	Good

Source: Building Financial Models, Bhaskar(1978, pg 318).

Appendix 3 First Year Sub-matrices of the CECROPF Model Standard Version

This appendix presents the formulation of the first year matrix of the CECROPF model standard version.

Such Matrix is subdivided into sub-matrices as shown in the Table A3.1 below.

Table A3.1 First Year Sub-matrices[1] of the CECROPF Model Standard Model

Standard Version												
Year 01												Transfers
A1.1	A1.2	A1.3	A1.4					A1.9	A1.10			
A2.1	A2.2	A2.3	A2.4	A2.5						A2.11	A2.12	
A3.1	A3.2	A3.3	A3.4	A3.5	A3.6	A3.7		A3.9	A3.10	A3.11	A3.12	
A4.1	A4.2				A4.6	A4.7	A4.8	A4.9	A4.10	A4.11	A4.12	
A5.1	A5.2	A5.3	A4.5		A5.6		A5.8	A5.9	A5.10	A5.11	A5.12	TA05.1
												TA06.1
												TA07.1
												TA08.1
												TA09.1
												TA10.1

[1]The sub-matrices A1.1,...,A5.12 describe the activities included in the first year period and the sub-matrices TA05.1,...,TA10.1 are transfer activities.

Sub-matrix A1.1

ACTIVITIES		Soil prep. No irrig. AVL10in	EVL10in	Irrigat. EVL102i	iHL102i	EVL101i	iHL101i	Crop act. soil LVAi0 1a10R	2a10R	1a10M	2a10M	1a10S	2a10S	soil LVEi0 1b10R	2b10R	1b10M	2b10M	1b10S	2b10S	soil LHii0 1c10R	2c10R
CONSTRAINTS																					
Soil classes (up land):																					
Y01LVAi0	20 =>	1.00																			
Y01LVEi0	45 =>		1.00																		
Irrigatable soils:																					
Y01LVEi2	15 =>			1.00																	
Y01LVEi1	0 =>			-1.00		1.00															
Y01LHii2	20 =>				1.00																
Y01LHii1	0 =>				-1.00		1.00														
Irrigation permission:																					
Y01ir1	0 =>					-1.00															
Y01ir2	0 =>						-1.00														
Water supply:																					
Y01ws1i1	0 =>																				
Y01ws1i2	0 =>																				
Y01ws2i1	0 =>																				
Y01ws2i2	0 =>																				
Soil preparation inv.:																					
Y01Lim05	0 =>	19.31	19.31	19.31	19.31																
Y01NtP05	0 =>	10.16	10.16	10.16	10.16																
Y01ChP10	0 =>	12.04	12.04	12.04	12.04	-12.04	-12.04														
Y01ChK10	0 =>	2.19	2.19	2.19	2.19	-2.19	-2.19														
Y01CMi10	0 =>	0.71	0.71	0.71	0.71	-0.71	-0.71														
Y01ChP05	0 =>					12.04	12.04														
Y01ChK05	0 =>					2.19	2.19														
Y01CMi05	0 =>					0.71	0.71														
Y01CCa05	0 =>				33.53																
Y01CSC05	0 =>	58.14																			
Y01CCe05	0 =>		67.49	67.49																	
Soil use ties:																					
Y01LVA0t	0 =>	-1.00						1.00	1.00	1.00	1.00	1.00	1.00								
Y01LVE0t	0 =>		-1.00	-1.00										1.00	1.00	1.00	1.00	1.00	1.00		
Y01LHi0t	0 =>				-1.00															1.00	1.00
Y01LVE1t	0 =>																				
Y01LHi1t	0 =>																				
Y01LVE2t	0 =>																				
Y01LHi2t	0 =>																				
Investments in assets:																					
Y01LT05a	0 =>																				
Y01LT05b	0 =>																				
Y01LT05c	0 =>																				
Family labour:																					
Y01FL05	200 =>																				
Y01FL06	200 =>																				
Y01FL07	200 =>																				
Y01FL08	200 =>																				
Y01FL09	200 =>																				
Y01FL10	200 =>							1.00	1.00	1.00	1.00			1.00	1.00	1.00	1.00			1.00	1.00
Y01FL11	200 =>											1.00	1.00					1.00	1.00		
Y01FL12	100 =>																				
Y01FL01	200 =>																				
Y01FL02	200 =>																				
Y01FL03	200 =>							1.00						1.00						1.00	
Y01FL04	200 =>								1.00			1.00	1.00		1.00			1.00	1.00		1.00

Sub-matrix A2.1

												............soil LVAi0.............						............soil LVEi0.............						soil LHii0	
	SEITIVITCA	. .perp lioS	girri oN	AVL10in	EVL10in	detagirrI	EVL102i	iHL102i	EVL101i	iHL101i	.tca porC	1a10R	2a10R	1a10M	2a10M	1a10S	2a10S	1b10R	2b10R	1b10M	2b10M	1b10S	2b10S	1c10R	2c10R
CONSTRAINTS																									
Employed tractor driver:																									
Y01TDPer	0 =>																								
Employed driver hours:																									
Y01EL05	0 =>																								
Y01EL06	0 =>																								
Y01EL07	0 =>																								
Y01EL08	0 =>																								
Y01EL09	0 =>											3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Y01EL10	0 =>											2.50	2.50	2.50	2.50	3.00	3.00	2.50	2.50	2.50	2.50	3.00	3.00	2.50	2.50
Y01EL11	0 =>															2.00	2.00					2.00	2.00		
Y01EL12	0 =>																								
Y01EL01	0 =>															1.00	1.00					1.00	1.00		
Y01EL02	0 =>																								
Y01EL03	0 =>											1.10						1.10						1.10	
Y01EL04	0 =>												1.10			1.10	1.10		1.10			1.10	1.10		1.10
Seasonal labour:																									
Y01SL10	0 =>											5.00	5.00	5.00	5.00			5.00	5.00	5.00	5.00			5.00	5.00
Y01SL11	0 =>													1.00	1.00	5.00	5.00			1.00	1.00	5.00	5.00		
Y01SL01	0 =>											4.00	4.00	28.00	28.00	2.00	2.00	4.00	4.00	28.00	28.00	2.00	2.00	4.00	4.00
Y01SL03	0 =>											1.00						1.00						1.00	
Y01SL04	0 =>												1.00			1.00	1.00		1.00			1.00	1.00		1.00
Tractor number:																									
Y01TN	1 =>																								
Available tractor hours:																									
Y01ST05	0 =>																								
Y01ST07	0 =>																								
Y01ST08	0 =>																								
Y01ST09	0 =>																								
Y01ST10	0 =>																								
Y01ST11	0 =>																								
Y01ST01	0 =>																								
Y01ST03	0 =>																								
Y01ST04	0 =>																								
Tractor requirements:																									
Y01TR05	0 =>																								
Y01TR07	0 =>																								
Y01TR08	0 =>																								
Y01TR09	0 =>											3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Y01TR10	0 =>											2.50	2.50	2.50	2.50	3.00	3.00	2.50	2.50	2.50	2.50	3.00	3.00	2.50	2.50
Y01TR11	0 =>															2.00	2.00					2.00	2.00		
Y01TR01	0 =>															1.00	1.00					1.00	1.00		
Y01TR03	0 =>											.10						.10						.10	
Y01TR04	0 =>												.10			.10	.10		.10			.10	.10		.10
Harvester requirements:																									
Y01HR09	0 =>																								
Y01HR03	0 =>											1.00						1.00						1.00	
Y01HR04	0 =>												1.00			1.00	1.00		1.00			1.00	1.00		1.00
Maintenace costs:																									
(family consumption)																									
Y01fc	1 =																								
(discretionary cons.)																									
Y01dc04	0 =>																								
(overhead costs)																									
Y01oc	1 =																								

Sub-matrix A3.1

												............soil LVAi0.............						............soil LVEi0.............						soil LHii0	
	SEITIVITCA	.perp lioS	.girri oN	AVL10in	EVL10in	detagirrI	EVL102i	iHL102i	EVL101i	iHL101i	.tca porC	1a10R	2a10R	1a10M	2a10M	1a10S	2a10S	1b10R	2b10R	1b10M	2b10M	1b10S	2b10S	1c10R	2c10R
CONSTRAINTS																									
Machine variable costs:																									
Y01MVC05	0 =>																								
Y01MVC07	0 =>																								
Y01MVC08	0 =>																								
Y01MVC09	0 =>																								
Y01MVC10	0 =>																								
Y01MVC11	0 =>																								
Y01MVC01	0 =>																								
Y01MVC03	0 =>																								
Y01MVC04	0 =>																								
Costs of direct inputs:																									
Y01CDI05	0 =>																								
Y01CDI07	0 =>																								
Y01CDI08	0 =>																								
Y01CDI09	0 =>																								
Y01CDI10	0 =>											10.45	10.45	23.82	23.82			10.45	10.45	23.82	23.82			10.45	10.45
Y01CDI11	0 =>															16.09	16.09					16.09	16.09		
Y01CDI01	0 =>																								
Y01CDI03	0 =>											1.65						1.65						1.65	
Y01CDI04	0 =>												1.65			2.44	2.44		1.65			2.44	2.44		1.65
Asset evaluation:																									
Y01AE04	0 =>			-44.41	-44.41		-44.41	-44.41																	
Working capital:																									
Y01WK05	2500. =>																								
Y01WK06	0 =>																								
Y01WK07	0 =>																								
Y01WK08	0 =>																								
Y01WK09	0 =>																								
Y01WK10	0 =>																								
Y01WK11	0 =>																								
Y01WK12	0 =>																								
Y01WK01	0 =>																								
Y01WK02	0 =>																								
Y01WK03	0 =>																								
Y01WK04	0 =>																								
Overdraft (short term):																									
Y01OD05	0 =>																								
Y01OD07	0 =>																								
Y01OD09	0 =>																								
Y01OD10	0 =>											-14.27	-14.27	-14.40	-14.40	-17.30	-17.30	-14.27	-14.27	-14.40	-14.40	-17.30	-17.30	-14.27	-14.27
Y01OD11	0 =>											-4.08	-4.08	-8.64	-8.64	-4.94	-4.94	-4.08	-4.08	-8.64	-8.64	-4.94	-4.94	-4.08	-4.08
Y01OD02	0 =>											-2.03	-2.03	-5.75	-5.75	-2.03	-2.03	-2.03	-2.03	-5.75	-5.75	-2.03	-2.03	-2.03	-2.03
Long term investments: (plan A)																									
Y01IA05	0 =>																								
Y01IA06	0 =>																								
Y01IA07	0 =>																								
Y01IA08	0 =>																								
Y01IA09	0 =>																								
Y01IA10	0 =>																								
Y01IA11	0 =>																								
Y01IA12	0 =>																								
Y01IA01	0 =>																								

Sub-matrix A4.1

ACTIVITIES		Soil prep.	No irrig.	ni01LVA	ni01LVE	Irrigat.	i201LVE	i201LHi	i101LVE	i101LHi	Crop.	............soil LVAi0............						............soil LVEi0............						soil LHii0	
												R01a1	R01a2	M01a1	M01a2	S01a1	S01a2	R01b1	R01b2	M01b1	M01b2	S01b1	S01b2	R01c1	R01c2
CONSTRAINTS																									
Long term investments: (plan A)																									
Y01IA02	0 =>																								
Y01IA03	0 =>																								
Y01IA04	0 =>																								
Long term investments: (plan B)																									
Y01IB05	0 =>																								
Y01IB06	0 =>																								
Y01IB07	0 =>																								
Y01IB08	0 =>																								
Y01IB09	0 =>																								
Y01IB10	0 =>																								
Y01IB11	0 =>																								
Y01IB12	0 =>																								
Y01IB01	0 =>																								
Y01IB02	0 =>																								
Y01IB03	0 =>																								
Y01IB04	0 =>																								
(plan C)																									
Y01IC05	0 =>																								
Y01IC06	0 =>																								
Y01IC07	0 =>																								
Y01IC08	0 =>																								
Y01IC09	0 =>																								
Y01IC10	0 =>																								
Y01IC11	0 =>																								
Y01IC12	0 =>																								
Y01IC01	0 =>																								
Y01IC02	0 =>																								
Y01IC03	0 =>																								
Y01IC04	0 =>																								
Market capital:																									
Y01MK05	1000. =>																								
Y01MK06	1000. =>																								
Y01MK07	1000. =>																								
Y01MK08	1000. =>																								
Y01MK09	1000. =>																								
Y01MK10	1000. =>																								
Y01MK11	1000. =>																								
Y01MK12	1000. =>																								
Y01MK01	1000. =>																								
Y01MK02	1000. =>																								
Y01MK03	1000. =>																								
Y01MK04	1000. =>																								
Production for sale: (irrig. supplied)																									
Y01W09	0 =>																								
(no irrigation)																									
Y01R03	0 =>											-20.						-24.						-20.	
Y01R04	0 =>												-20.8						-24.5						-22.7
Y01S04	0 =>															-30.	-33.					-34.	-35.5		
Y02M05	0 =>													-80.	-82.					-83.	-85.5				

Sub-matrix A5.1

CONSTRAINTS	SEITIVITCA	..perp lioS	..girri oN	AVL10in	EVL10in	.tagirrI	EVL102i	iHL102i	EVL101i	iHL101i	.tca porC	soil LVAi0 1a10R	soil LVAi0 2a10R	soil LVAi0 1a10M	soil LVAi0 2a10M	soil LVAi0 1a10S	soil LVAi0 2a10S	soil LVEi0 1b10R	soil LVEi0 2b10R	soil LVEi0 1b10M	soil LVEi0 2b10M	soil LVEi0 1b10S	soil LVEi0 2b10S	soil LHii0 1c10R	soil LHii0 2c10R
Income ties:																									
Y01IT09	0 =>																								
Y01IT10	0 =>																								
Y01IT11	0 =>																								
Y01IT12	0 =>																								
Y01IT01	0 =>																								
Y01IT02	0 =>																								
Y01IT03	0 =>																								
Y01IT04	0 =>																								
Pos-tax income:																									
Y01PTI	0 =																								
Income allocation:																									
Y01Y1	0 =																								
Used soil ties:																									
(no irrigated soil)																									
T1LVA0t	0 =>			1.00																					
T1LVE0t	0 =>				1.00																				
(irrigate soil)																									
T1LVE2t	0 =>						1.00																		
T1LHi2t	0 =>							1.00																	
Rotation ties:																									
T1cLVA0	0 =>											-1.00	-1.00	-1.00	-1.00										
T1lLVA0	0 =>															-1.00	-1.00								
T1cLVE0	0 =>																	-1.00	-1.00	-1.00	-1.00				
T1lLVE0	0 =>																					-1.00	-1.00		
T1cLHi0	0 =>																							-1.00	-1.00
T1lLHi0	0 =>																								
T1lLVE2	0 =>																								
T1lLHi2	0 =>																								
Irrigation system ties:																									
T1IS1t	0 =>																								
T1IS2t	0 =>																								
Tractor aquisition tie:																									
T1ST1t	0 =>																								
Overdraft bills:																									
T1Ob05t	0 =>																								
T1Ob06t	0 =>																								
Mortgage:																									
T1MOA	0 =>																								
T1MOB	0 =>																								
T1MOC	0 =>																								
Asset value:																									
T1Av	0 =>																								
Production carry-over:																									
T1Rco	0 =>																								
T1Sco	0 =>																								
Farm business cash:																									
T1Fbc	0 =>																								
Farm business deficit:																									
T1Fbd	0 =>																								

Sub-matrix A1.2

	ACTIVITIES	Crop act.												Other Management act.							
		......soil LHii0......				soil LVEi1		soil LHii1		soil LVEi2		soil LHii2									
		M01c1	M01c2	S01c1	S01c2	W01d1	W01d2	W01e1	W01e2	S01f1	S01f2	S01g1	S01g2	Man0105	Man0106	Man0107	Man0108	Man0109	Man0110	Man0111	Man0112
CONSTRAINTS																					
Soil classes (up land):																					
Y01LVAi0	20 =>																				
Y01LVEi0	45 =>																				
Irrigatable soils:																					
Y01LVEi2	15 =>																				
Y01LVEi1	0 =>																				
Y01LHii2	20 =>																				
Y01LHii1	0 =>																				
Irrigation permission:																					
Y01ir1	0 =>																				
Y01ir2	0 =>																				
Water supply:																					
Y01ws1i1	0 =>							440.	440.												
Y01ws1i2	0 =>											200.	200.								
Y01ws2i1	0 =>					480.	480.														
Y01ws2i2	0 =>									200.	200.										
Soil preparation inv.:																					
Y01Lim05	0 =>																				
Y01NtP05	0 =>																				
Y01ChP10	0 =>																				
Y01ChK10	0 =>																				
Y01CMi10	0 =>																				
Y01ChP05	0 =>																				
Y01ChK05	0 =>																				
Y01CMi05	0 =>																				
Y01CCa05	0 =>																				
Y01CSC05	0 =>																				
Y01CCe05	0 =>																				
Soil use ties:																					
Y01LVA0t	0 =>																				
Y01LVE0t	0 =>																				
Y01LHi0t	0 =>	1.00	1.00	1.00	1.00																
Y01LVE1t	0 =>					1.00	1.00														
Y01LHi1t	0 =>							1.00	1.00												
Y01LVE2t	0 =>					-1.00	-1.00			1.00	1.00										
Y01LHi2t	0 =>							-1.00	-1.00			1.00	1.00								
Investments in assets:																					
Y01LT05a	0 =>																				
Y01LT05b	0 =>																				
Y01LT05c	0 =>																				
Family labour:																					
Y01FL05	200 =>					1.00	1.00	1.00	1.00					1.00							
Y01FL06	200 =>														1.00						
Y01FL07	200 =>					0.30	0.30	0.30	0.30							1.00					
Y01FL08	200 =>					0.30	0.30	0.30	0.30								1.00				
Y01FL09	200 =>					1.00	1.00	1.00	1.00									1.00			
Y01FL10	200 =>	1.00	1.00																1.00		
Y01FL11	200 =>			1.00	1.00					1.00	1.00	1.00	1.00							1.00	
Y01FL12	100 =>																				1.00
Y01FL01	200 =>																				
Y01FL02	200 =>																				
Y01FL03	200 =>																				
Y01FL04	200 =>			1.00	1.00					1.00	1.00	1.00	1.00								

Sub-matrix A2.2

ACTIVITIES	Crop act.	......soil LHii0......				soil LVEi1		soil LHii1		soil LVEi2		soil LHii2		Other act. Management	Man0105	Man0106	Man0107	Man0108	Man0109	Man0110	Man0111	Man0112
		M01c1	M01c2	S01c1	S01c2	W01d1	W01d2	W01e1	W01e2	S01f1	S01f2	S01g1	S01g2									
CONSTRAINTS																						
Employed tractor driver:																						
Y01TDPer	0 =>													:								
Employed driver hours:																						
Y01EL05	0 =>					6.10	6.10	6.10	6.10													
Y01EL06	0 =>																					
Y01EL07	0 =>					0.70	0.70	0.70	0.70													
Y01EL08	0 =>					0.40	0.40	0.40	0.40													
Y01EL09	0 =>	3.00	3.00	3.00	3.00	1.10	1.10	1.10	1.10	3.00	3.00	3.00	3.00									
Y01EL10	0 =>	2.50	2.50	3.00	3.00					3.00	3.00	3.00	3.00									
Y01EL11	0 =>			2.00	2.00					2.00	2.00	2.00	2.00									
Y01EL12	0 =>																					
Y01EL01	0 =>			1.00	1.00					1.00	1.00	1.00	1.00									
Y01EL02	0 =>																					
Y01EL03	0 =>																					
Y01EL04	0 =>			1.10	1.10					1.10	1.10	1.10	1.10									
Seasonal labour:																						
Y01SL10	0 =>	5.00	5.00																			
Y01SL11	0 =>	1.00	1.00	5.00	5.00					5.00	5.00	5.00	5.00									
Y01SL01	0 =>	28.00	28.00	2.00	2.00					2.00	2.00	2.00	2.00									
Y01SL03	0 =>																					
Y01SL04	0 =>			1.00	1.00					1.00	1.00	1.00	1.00									
Tractor number:																						
Y01TN	1 =>																					
Available tractor hours:																						
Y01ST05	0 =>																					
Y01ST07	0 =>																					
Y01ST08	0 =>																					
Y01ST09	0 =>																					
Y01ST10	0 =>																					
Y01ST11	0 =>																					
Y01ST01	0 =>																					
Y01ST03	0 =>																					
Y01ST04	0 =>																					
Tractor requirements:																						
Y01TR05	0 =>					6.10	6.10	6.10	6.10													
Y01TR07	0 =>					0.70	0.70	0.70	0.70													
Y01TR08	0 =>					0.40	0.40	0.40	0.40													
Y01TR09	0 =>	3.00	3.00	3.00	3.00	0.10	0.10	0.10	0.10	3.00	3.00	3.00	3.00									
Y01TR10	0 =>	2.50	2.50	3.00	3.00					3.00	3.00	3.00	3.00									
Y01TR11	0 =>			2.00	2.00					2.00	2.00	2.00	2.00									
Y01TR01	0 =>			1.00	1.00					1.00	1.00	1.00	1.00									
Y01TR03	0 =>																					
Y01TR04	0 =>			.10	.10					.10	.10	.10	.10									
Harvester requirements:																						
Y01HR09	0 =>					1.00	1.00	1.00	1.00													
Y01HR03	0 =>																					
Y01HR04	0 =>			1.00	1.00					1.00	1.00	1.00	1.00									
Maintenace costs:																						
(family consumption)																						
Y01fc	1 =																					
(discretionary cons.)																						
Y01dc04	0 =>																					
(overhead costs)																						
Y01oc	1 =																					

Sub-matrix A3.2

ACTIVITIES	Crop act.	......soil LHii0......				soil LVEi1		soil LHii1		soil LVEi2		soil LHii2		Other act. Management							
		M01c1	M01c2	S01c1	S01c2	W01d1	W01d2	W01e1	W01e2	S01f1	S01f2	S01g1	S01g2	Man0105	Man0106	Man0107	Man0108	Man0109	Man0110	Man0111	Man0112
CONSTRAINTS																					
Machine variable costs:																					
Y01MVC05	0 =>																				
Y01MVC07	0 =>																				
Y01MVC08	0 =>																				
Y01MVC09	0 =>																				
Y01MVC10	0 =>																				
Y01MVC11	0 =>																				
Y01MVC01	0 =>																				
Y01MVC03	0 =>																				
Y01MVC04	0 =>																				
Costs of direct inputs:																					
Y01CDI05	0 =>					18.34	18.34	18.34	18.34												
Y01CDI07	0 =>					3.84	3.84	3.84	3.84												
Y01CDI08	0 =>					2.75	2.75	2.75	2.75												
Y01CDI09	0 =>					2.57	2.57	2.57	2.57												
Y01CDI10	0 =>	23.82	23.82																		
Y01CDI11	0 =>			16.09	16.09					16.09	16.09	16.09	16.09								
Y01CDI01	0 =>																				
Y01CDI03	0 =>																				
Y01CDI04	0 =>			2.44	2.44					2.44	2.44	2.44	2.44								
Asset evaluation:																					
Y01AE04	0 =>																				
Working capital:																					
Y01WK05	2500. =>																				
Y01WK06	0 =>																				
Y01WK07	0 =>																				
Y01WK08	0 =>																				
Y01WK09	0 =>																				
Y01WK10	0 =>																				
Y01WK11	0 =>																				
Y01WK12	0 =>																				
Y01WK01	0 =>																				
Y01WK02	0 =>																				
Y01WK03	0 =>																				
Y01WK04	0 =>																				
Overdraft (short term):																					
Y01OD05	0 =>					-19.78	-19.78	-19.78	-19.78												
Y01OD07	0 =>					-5.65	-5.65	-5.65	-5.65												
Y01OD09	0 =>					-2.83	-2.83	-2.83	-2.83												
Y01OD10	0 =>	-14.40	-14.40	-17.30	-17.30					-17.30	-17.30	-17.30	-17.30								
Y01OD11	0 =>	-8.64	-8.64	-4.94	-4.94					-4.94	-4.94	-4.94	-4.94								
Y01OD02	0 =>	-5.75	-5.75	-2.03	-2.03					-2.03	-2.03	-2.03	-2.03								
Long term investments: (plan A)																					
Y01IA05	0 =>																				
Y01IA06	0 =>																				
Y01IA07	0 =>																				
Y01IA08	0 =>																				
Y01IA09	0 =>																				
Y01IA10	0 =>																				
Y01IA11	0 =>																				
Y01IA12	0 =>																				
Y01IA01	0 =>																				

Sub-matrix A4.2

CONSTRAINTS / ACTIVITIES	Crop act.	soil LHii0 M01c1	soil LHii0 M01c2	soil LHii0 S01c1	soil LHii0 S01c2	soil LVEi1 W01d1	soil LVEi1 W01d2	soil LHii1 W01e1	soil LHii1 W01e2	soil LVEi2 S01f1	soil LVEi2 S01f2	soil LHii2 S01g1	soil LHii2 S01g2	Other act. Management	Man0105	Man0106	Man0107	Man0108	Man0109	Man0110	Man0111	Man0112
Long term investments: (plan A)																						
Y01IA02	0 =>																					
Y01IA03	0 =>																					
Y01IA04	0 =>																					
Long term investments: (plan B)																						
Y01IB05	0 =>																					
Y01IB06	0 =>																					
Y01IB07	0 =>																					
Y01IB08	0 =>																					
Y01IB09	0 =>																					
Y01IB10	0 =>																					
Y01IB11	0 =>																					
Y01IB12	0 =>																					
Y01IB01	0 =>																					
Y01IB02	0 =>																					
Y01IB03	0 =>																					
Y01IB04	0 =>																					
(plan C)																						
Y01IC05	0 =>																					
Y01IC06	0 =>																					
Y01IC07	0 =>																					
Y01IC08	0 =>																					
Y01IC09	0 =>																					
Y01IC10	0 =>																					
Y01IC11	0 =>																					
Y01IC12	0 =>																					
Y01IC01	0 =>																					
Y01IC02	0 =>																					
Y01IC03	0 =>																					
Y01IC04	0 =>																					
Market capital:																						
Y01MK05	1000. =>																					
Y01MK06	1000. =>																					
Y01MK07	1000. =>																					
Y01MK08	1000. =>																					
Y01MK09	1000. =>																					
Y01MK10	1000. =>																					
Y01MK11	1000. =>																					
Y01MK12	1000. =>																					
Y01MK01	1000. =>																					
Y01MK02	1000. =>																					
Y01MK03	1000. =>																					
Y01MK04	1000. =>																					
Production for sale: (irrig. supplied)																						
Y01W09	0 =>					-31.	-33.	-32.	-30.													
(no irrigation)																						
Y01R03	0 =>																					
Y01R04	0 =>																					
Y01S04	0 =>			-33.	-35.6					-45.	-50.	-52.	-53.6									
Y02M05	0 =>	-80.4	-78.																			

Sub-matrix A5.2

ACTIVITIES		Crop act.	......soil LHii0......				soil LVEi1		soil LHii1		soil LVEi2		soil LHii2		Other Management act.								
			M01c1	M01c2	S01c1	S01c2	W01d1	W01d2	W01e1	W01e2	S01f1	S01f2	S01g1	S01g2		Man0105	Man0106	Man0107	Man0108	Man0109	Man0110	Man0111	Man0112
CONSTRAINTS																							
Income ties:																							
Y01IT09	0 =>																						
Y01IT10	0 =>																						
Y01IT11	0 =>																						
Y01IT12	0 =>																						
Y01IT01	0 =>																						
Y01IT02	0 =>																						
Y01IT03	0 =>																						
Y01IT04	0 =>																						
Pos-tax income:																							
Y01PTI	0 =															-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
Income allocation:																							
Y01Y1	0 =																						
Used soil ties:																							
(no irrigated soil)																							
T1LVA0t	0 =>																						
T1LVE0t	0 =>																						
(irrigate soil)																							
T1LVE2t	0 =>																						
T1LHi2t	0 =>																						
Rotation ties:																							
T1cLVA0	0 =>																						
T1lLVA0	0 =>																						
T1cLVE0	0 =>																						
T1lLVE0	0 =>																						
T1cLHi0	0 =>		-1.00	-1.00																			
T1lLHi0	0 =>				-1.00	-1.00																	
T1lLVE2	0 =>										-1.00	-1.00											
T1lLHi2	0 =>												-1.00	-1.00									
Irrigation system ties:																							
T1IS1t	0 =>																						
T1IS2t	0 =>																						
Tractor aquisition tie:																							
T1ST1t	0 =>																						
Overdraft bills:																							
T1Ob05t	0 =>																						
T1Ob06t	0 =>																						
Mortgage:																							
T1MOA	0 =>																						
T1MOB	0 =>																						
T1MOC	0 =>																						
Asset value:																							
T1Av	0 =>																						
Production carry-over:																							
T1Rco	0 =>																						
T1Sco	0 =>																						
Farm business cash:																							
T1Fbc	0 =>																						
Farm business deficit:																							
T1Fbd	0 =>																						

Sub-matrix A1.3

CONSTRAINTS	ACTIVITIES	Other management act.	Man0101	Man0102	Man0103	Man0104	Production Pro0105	Pro0106	Pro0107	Pro0108	Pro0109	Pro0110	Pro0111	Pro0112	Pro0101	Pro0102	Pro0103	Pro0104	Investments Plans -A- IS01A1	IS01A2	ST01A1	Plans -B- IS01B1
Soil classes (up land):																						
Y01LVAi0	20 =>																					
Y01LVEi0	45 =>																					
Irrigatable soils:																						
Y01LVEi2	15 =>																					
Y01LVEi1	0 =>																					
Y01LHii2	20 =>																					
Y01LHii1	0 =>																					
Irrigation permission:																						
Y01ir1	0 =>																		1.00			1.00
Y01ir2	0 =>																			1.00		
Water supply:																						
Y01ws1i1	0 =>																		-440.			-440.
Y01ws1i2	0 =>																		-200.			-200.
Y01ws2i1	0 =>																			-480.		
Y01ws2i2	0 =>																			-200.		
Soil preparation inv.:																						
Y01Lim05	0 =>																					
Y01NtP05	0 =>																					
Y01ChP10	0 =>																					
Y01ChK10	0 =>																					
Y01CMi10	0 =>																					
Y01ChP05	0 =>																					
Y01ChK05	0 =>																					
Y01CMi05	0 =>																					
Y01CCa05	0 =>																					
Y01CSC05	0 =>																					
Y01CCe05	0 =>																					
Soil use ties:																						
Y01LVA0t	0 =>																					
Y01LVE0t	0 =>																			1.00		
Y01LHi0t	0 =>																		1.00			1.00
Y01LVE1t	0 =>																			-1.00		
Y01LHi1t	0 =>																		-1.00			-1.00
Y01LVE2t	0 =>																					
Y01LHi2t	0 =>																					
Investments in assets:																						
Y01LT05a	0 =>																		200.	200.	6700.	
Y01LT05b	0 =>																					200.
Y01LT05c	0 =>																					
Family labour:																						
Y01FL05	200 =>																					
Y01FL06	200 =>																					
Y01FL07	200 =>																					
Y01FL08	200 =>																					
Y01FL09	200 =>																					
Y01FL10	200 =>																					
Y01FL11	200 =>																					
Y01FL12	100 =>																					
Y01FL01	200 =>		1.00																			
Y01FL02	200 =>			1.00																		
Y01FL03	200 =>				1.00																	
Y01FL04	200 =>					1.00																

Sub-matrix A2.3

ACTIVITIES		Other act. Management	Man0101	Man0102	Man0103	Man0104	Production	Pro0105	Pro0106	Pro0107	Pro0108	Pro0109	Pro0110	Pro0111	Pro0112	Pro0101	Pro0102	Pro0103	Pro0104	Investments	Plans -A- IS01A1	Plans -A- IS01A2	Plans -A- ST01A1	Plans -B- IS01B1
CONSTRAINTS																								
Employed tractor driver:																								
Y01TDPer	0 =>																						-1.00	
Employed driver hours:																								
Y01EL05	0 =>							1.00																
Y01EL06	0 =>								1.00															
Y01EL07	0 =>									1.00														
Y01EL08	0 =>										1.00													
Y01EL09	0 =>											1.00												
Y01EL10	0 =>												1.00											
Y01EL11	0 =>													1.00										
Y01EL12	0 =>														1.00									
Y01EL01	0 =>															1.00								
Y01EL02	0 =>																1.00							
Y01EL03	0 =>																	1.00						
Y01EL04	0 =>																		1.00					
Seasonal labour:																								
Y01SL10	0 =>																							
Y01SL11	0 =>																							
Y01SL01	0 =>																							
Y01SL03	0 =>																							
Y01SL04	0 =>																							
Tractor number:																								
Y01TN	1 =>																						1.00	
Available tractor hours:																								
Y01ST05	0 =>																						-200.00	
Y01ST07	0 =>																						-200.00	
Y01ST08	0 =>																						-200.00	
Y01ST09	0 =>																						-200.00	
Y01ST10	0 =>																						-200.00	
Y01ST11	0 =>																						-200.00	
Y01ST01	0 =>																						-200.00	
Y01ST03	0 =>																						-200.00	
Y01ST04	0 =>																						-200.00	
Tractor requirements:																								
Y01TR05	0 =>																							
Y01TR07	0 =>																							
Y01TR08	0 =>																							
Y01TR09	0 =>																							
Y01TR10	0 =>																							
Y01TR11	0 =>																							
Y01TR01	0 =>																							
Y01TR03	0 =>																							
Y01TR04	0 =>																							
Harvester requirements:																								
Y01HR09	0 =>																							
Y01HR03	0 =>																							
Y01HR04	0 =>																							
Maintenace costs:																								
(family consumption)																								
Y01fc	1 =																							
(discretionary cons.)																								
Y01dc04	0 =>																							
(overhead costs)																								
Y01oc	1 =																							

Sub-matrix A3.3

ACTIVITIES		Other management act.				Production												Investments: Plans -A-			Investments: Plans -B-
CONSTRAINTS		Man0101	Man0102	Man0103	Man0104	Pro0105	Pro0106	Pro0107	Pro0108	Pro0109	Pro0110	Pro0111	Pro0112	Pro0101	Pro0102	Pro0103	Pro0104	IS01A1	IS01A2	ST01A1	IS01B1
Machine variable costs:																					
Y01MVC05	0 =>																				
Y01MVC07	0 =>																				
Y01MVC08	0 =>																				
Y01MVC09	0 =>																				
Y01MVC10	0 =>																				
Y01MVC11	0 =>																				
Y01MVC01	0 =>																				
Y01MVC03	0 =>																				
Y01MVC04	0 =>																				
Costs of direct inputs:																					
Y01CDI05	0 =>																				
Y01CDI07	0 =>																				
Y01CDI08	0 =>																				
Y01CDI09	0 =>																				
Y01CDI10	0 =>																				
Y01CDI11	0 =>																				
Y01CDI01	0 =>																				
Y01CDI03	0 =>																				
Y01CDI04	0 =>																				
Asset evaluation:																					
Y01AE04	0 =>																	-220.	-220.	-7100.	-220.
Working capital:																					
Y01WK05	2500. =>																	20.	20.	400.	20.
Y01WK06	0 =>																				
Y01WK07	0 =>																				
Y01WK08	0 =>																				
Y01WK09	0 =>																				
Y01WK10	0 =>																				
Y01WK11	0 =>																				
Y01WK12	0 =>																				
Y01WK01	0 =>																				
Y01WK02	0 =>																				
Y01WK03	0 =>																				
Y01WK04	0 =>																				
Overdraft (short term):																					
Y01OD05	0 =>																				
Y01OD07	0 =>																				
Y01OD09	0 =>																				
Y01OD10	0 =>																				
Y01OD11	0 =>																				
Y01OD02	0 =>																				
Long term investments: (plan A)																					
Y01IA05	0 =>																				
Y01IA06	0 =>																				
Y01IA07	0 =>																				
Y01IA08	0 =>																				
Y01IA09	0 =>																				
Y01IA10	0 =>																				
Y01IA11	0 =>																				
Y01IA12	0 =>																				
Y01IA01	0 =>																				

Sub-matrix A5.3

ACTIVITIES		Other management	Man0101	Man0102	Man0103	Man0104	Production Pro0105	Pro0106	Pro0107	Pro0108	Pro0109	Pro0110	Pro0111	Pro0112	Pro0101	Pro0102	Pro0103	Pro0104	Investments Plans -A- IS01A1	Plans -A- IS01A2	Plans -A- ST01A1	Plans -B- IS01B1
CONSTRAINTS																						
Income ties:																						
Y01IT09	0 =>																					
Y01IT10	0 =>																					
Y01IT11	0 =>																					
Y01IT12	0 =>																					
Y01IT01	0 =>																					
Y01IT02	0 =>																					
Y01IT03	0 =>																					
Y01IT04	0 =>																					
Pos-tax income:																						
Y01PTI	0 =		-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01				
Income allocation:																						
Y01Y1	0 =																					
Used soil ties:																						
(no irrigated soil)																						
T1LVA0t	0 =>																					
T1LVE0t	0 =>																					
(irrigate soil)																						
T1LVE2t	0 =>																					
T1LHi2t	0 =>																					
Rotation ties:																						
T1cLVA0	0 =>																					
T1lLVA0	0 =>																					
T1cLVE0	0 =>																					
T1lLVE0	0 =>																					
T1cLHi0	0 =>																					
T1lLHi0	0 =>																					
T1lLVE2	0 =>																					
T1lLHi2	0 =>																					
Irrigation system ties:																						
T1IS1t	0 =>																		-1.00			-1.00
T1IS2t	0 =>																			-1.00		
Tractor aquisition tie:																						
T1ST1t	0 =>																				-1.00	
Overdraft bills:																						
T1Ob05t	0 =>																					
T1Ob06t	0 =>																					
Mortgage:																						
T1MOA	0 =>																					
T1MOB	0 =>																					
T1MOC	0 =>																					
Asset value:																						
T1Av	0 =>																					
Production carry-over:																						
T1Rco	0 =>																					
T1Sco	0 =>																					
Farm business cash:																						
T1Fbc	0 =>																					
Farm business deficit:																						
T1Fbd	0 =>																					

Sub-matrix A1.4

		...........Plans.............																						
ACTIVITIES	Investments	---B--- IS01B2	ST01B1	---C--- IS01C1	IS01C2	ST01C1	Own tractor	ST0105	ST0107	ST0108	ST0109	ST0110	ST0111	ST0101	ST0103	ST0104	Labour employed	EW01I	Seasonal	Sl0110	Sl0111	Sl0101	Sl0103	Sl0104
CONSTRAINTS																								
Soil classes (up land):																								
Y01LVAi0	20 =>																							
Y01LVEi0	45 =>																							
Irrigatable soils:																								
Y01LVEi2	15 =>																							
Y01LVEi1	0 =>																							
Y01LHii2	20 =>																							
Y01LHii1	0 =>																							
Irrigation permission:																								
Y01ir1	0 =>			1.00																				
Y01ir2	0 =>	1.00			1.00																			
Water supply:																								
Y01ws1i1	0 =>			-440.																				
Y01ws1i2	0 =>			-200.																				
Y01ws2i1	0 =>	-480.			-480.																			
Y01ws2i2	0 =>	-200.			-200.																			
Soil preparation inv.:																								
Y01Lim05	0 =>																							
Y01NtP05	0 =>																							
Y01ChP10	0 =>																							
Y01ChK10	0 =>																							
Y01CMi10	0 =>																							
Y01ChP05	0 =>																							
Y01ChK05	0 =>																							
Y01CMi05	0 =>																							
Y01CCa05	0 =>																							
Y01CSC05	0 =>																							
Y01CCe05	0 =>																							
Soil use ties:																								
Y01LVA0t	0 =>																							
Y01LVE0t	0 =>	1.00			1.00																			
Y01LHi0t	0 =>			1.00																				
Y01LVE1t	0 =>	-1.00			-1.00																			
Y01LHi1t	0 =>			-1.00																				
Y01LVE2t	0 =>																							
Y01LHi2t	0 =>																							
Investments in assets:																								
Y01LT05a	0 =>																							
Y01LT05b	0 =>	200.	6700.																					
Y01LT05c	0 =>			200.	200.	6700.																		
Family labour:																								
Y01FL05	200 =>																							
Y01FL06	200 =>																							
Y01FL07	200 =>																							
Y01FL08	200 =>																							
Y01FL09	200 =>																							
Y01FL10	200 =>																							
Y01FL11	200 =>																							
Y01FL12	100 =>																							
Y01FL01	200 =>																							
Y01FL02	200 =>																							
Y01FL03	200 =>																							
Y01FL04	200 =>																							

Sub-matrix A2.4

ACTIVITIES		Investments: IS01B2 (Plans B)	ST01B1 (Plans B)	IS01C1 (Plans C)	IS01C2 (Plans C)	ST01C1 (Plans C)	Own tractor: ST0105	ST0107	ST0108	ST0109	ST0110	ST0111	ST0101	ST0103	ST0104	Labour employed: EW01I	Seasonal: Sl0110	Sl0111	Sl0101	Sl0103	Sl0104
CONSTRAINTS																					
Employed tractor driver:																					
Y01TDPer	0 =>		-1.00			-1.00										1.0					
Employed driver hours:																					
Y01EL05	0 =>															-208.0					
Y01EL06	0 =>															-208.0					
Y01EL07	0 =>															-208.0					
Y01EL08	0 =>															-208.0					
Y01EL09	0 =>															-208.0					
Y01EL10	0 =>															-208.0					
Y01EL11	0 =>															-208.0					
Y01EL12	0 =>															-100.0					
Y01EL01	0 =>															-208.0					
Y01EL02	0 =>															-100.0					
Y01EL03	0 =>															-208.0					
Y01EL04	0 =>															-208.0					
Seasonal labour:																					
Y01SL10	0 =>																-8.00				
Y01SL11	0 =>																	-8.00			
Y01SL01	0 =>																		-8.00		
Y01SL03	0 =>																			-8.00	
Y01SL04	0 =>																				-8.00
Tractor number:																					
Y01TN	1 =>		1.00			1.00															
Available tractor hours:																					
Y01ST05	0 =>		-200.00			-200.00	1.00														
Y01ST07	0 =>		-200.00			-200.00		1.00													
Y01ST08	0 =>		-200.00			-200.00			1.00												
Y01ST09	0 =>		-200.00			-200.00				1.00											
Y01ST10	0 =>		-200.00			-200.00					1.00										
Y01ST11	0 =>		-200.00			-200.00						1.00									
Y01ST01	0 =>		-200.00			-200.00							1.00								
Y01ST03	0 =>		-200.00			-200.00								1.00							
Y01ST04	0 =>		-200.00			-200.00									1.00						
Tractor requirements:																					
Y01TR05	0 =>						-1.00														
Y01TR07	0 =>							-1.00													
Y01TR08	0 =>								-1.00												
Y01TR09	0 =>									-1.00											
Y01TR10	0 =>										-1.00										
Y01TR11	0 =>											-1.00									
Y01TR01	0 =>												-1.00								
Y01TR03	0 =>													-1.00							
Y01TR04	0 =>														-1.00						
Harvester requirements:																					
Y01HR09	0 =>																				
Y01HR03	0 =>																				
Y01HR04	0 =>																				
Maintenace costs:																					
(family consumption)																					
Y01fc	1 =																				
(discretionary cons.)																					
Y01dc04	0 =>																				
(overhead costs)																					
Y01oc	1 =																				

Sub-matrix A3.4

ACTIVITIES	Investments	Plans B: IS01B2	Plans B: ST01B1	Plans C: IS01C1	Plans C: IS01C2	Plans C: ST01C1	Own tractor	ST0105	ST0107	ST0108	ST0109	ST0110	ST0111	ST0101	ST0103	ST0104	Labour employed	EW01I	Seasonal	SL0110	SL0111	SL0101	SL0103	SL0104
CONSTRAINTS																								
Machine variable costs:																								
Y01MVC05	0 =>							0.88																
Y01MVC07	0 =>								0.88															
Y01MVC08	0 =>									0.88														
Y01MVC09	0 =>										0.88													
Y01MVC10	0 =>											0.88												
Y01MVC11	0 =>												0.88											
Y01MVC01	0 =>													0.88										
Y01MVC03	0 =>														0.88									
Y01MVC04	0 =>															0.88								
Costs of direct inputs:																								
Y01CDI05	0 =>																							
Y01CDI07	0 =>																							
Y01CDI08	0 =>																							
Y01CDI09	0 =>																							
Y01CDI10	0 =>																			0.36				
Y01CDI11	0 =>																				0.36			
Y01CDI01	0 =>																					0.36		
Y01CDI03	0 =>																						0.36	
Y01CDI04	0 =>																							0.36
Asset evaluation:																								
Y01AE04	0 =>	-220.	-7100.	-220.	-220.	-7100.																		
Working capital:																								
Y01WK05	2500. =>	20.	400.	20.	20.	400.												15.2						
Y01WK06	0 =>																	15.2						
Y01WK07	0 =>																	15.2						
Y01WK08	0 =>																	15.2						
Y01WK09	0 =>																	15.2						
Y01WK10	0 =>																	15.2						
Y01WK11	0 =>																	15.2						
Y01WK12	0 =>																	15.2						
Y01WK01	0 =>																	15.2						
Y01WK02	0 =>																	15.2						
Y01WK03	0 =>																	15.2						
Y01WK04	0 =>																	30.4						
Overdraft (short term):																								
Y01OD05	0 =>																							
Y01OD07	0 =>																							
Y01OD09	0 =>																							
Y01OD10	0 =>																							
Y01OD11	0 =>																							
Y01OD02	0 =>																							
Long term investments: (plan A)																								
Y01IA05	0 =>																							
Y01IA06	0 =>																							
Y01IA07	0 =>																							
Y01IA08	0 =>																							
Y01IA09	0 =>																							
Y01IA10	0 =>																							
Y01IA11	0 =>																							
Y01IA12	0 =>																							
Y01IA01	0 =>																							

Sub-matrix A5.4

CONSTRAINTS	ACTIVITIES	Investments: Plans B: IS01B2	Plans B: ST01B1	Plans C: IS01C1	Plans C: IS01C2	Plans C: ST01C1	Own tractor	ST0105	ST0107	ST0108	ST0109	ST0110	ST0111	ST0101	ST0103	ST0104	Labour Employed	EW01I	Seasonal	Sl0110	Sl0111	Sl0101	Sl0103	Sl0104
Income ties:																								
Y01IT09	0 =>																							
Y01IT10	0 =>																							
Y01IT11	0 =>																							
Y01IT12	0 =>																							
Y01IT01	0 =>																							
Y01IT02	0 =>																							
Y01IT03	0 =>																							
Y01IT04	0 =>																							
Pos-tax income:																								
Y01PTI	0 =																							
Income allocation:																								
Y01Y1	0 =																							
Used soil ties:																								
(no irrigated soil)																								
T1LVA0t	0 =>																							
T1LVE0t	0 =>																							
(irrigate soil)																								
T1LVE2t	0 =>																							
T1LHi2t	0 =>																							
Rotation ties:																								
T1cLVA0	0 =>																							
T1lLVA0	0 =>																							
T1cLVE0	0 =>																							
T1lLVE0	0 =>																							
T1cLHi0	0 =>																							
T1lLHi0	0 =>																							
T1lLVE2	0 =>																							
T1lLHi2	0 =>																							
Irrigation system ties:																								
T1IS1t	0 =>			-1.00																				
T1IS2t	0 =>	-1.00			-1.00																			
Tractor aquisition tie:																								
T1ST1t	0 =>		-1.00			-1.00																		
Overdraft bills:																								
T1Ob05t	0 =>																							
T1Ob06t	0 =>																							
Mortgage:																								
T1MOA	0 =>																							
T1MOB	0 =>																							
T1MOC	0 =>																							
Asset value:																								
T1Av	0 =>																							
Production carry-over:																								
T1Rco	0 =>																							
T1Sco	0 =>																							
Farm business cash:																								
T1Fbc	0 =>																							
Farm business deficit:																								
T1Fbd	0 =>																							

Sub-matrix A2.5

		Hired Tractor mach.									Harvester			Capital ....Transfer....								
CONSTRAINTS	ACTIVITIES	HT0105	HT0107	HT0108	HT0109	HT0110	HT0111	HT0101	HT0103	HT0104	HH0109	HH0103	HH0104	CT0105	CT0106	CT0107	CT0108	CT0109	CT0110	CT0111	CT0112	CT0101
Employed tractor driver:																						
Y01TDPer	0 =>																					
Employed driver hours:																						
Y01EL05	0 =>	-1.00																				
Y01EL06	0 =>																					
Y01EL07	0 =>		-1.00																			
Y01EL08	0 =>			-1.00																		
Y01EL09	0 =>				-1.00						-1.00											
Y01EL10	0 =>					-1.00																
Y01EL11	0 =>						-1.00															
Y01EL12	0 =>																					
Y01EL01	0 =>							-1.00														
Y01EL02	0 =>																					
Y01EL03	0 =>								-1.00			-1.00										
Y01EL04	0 =>									-1.00			-1.00									
Seasonal labour:																						
Y01SL10	0 =>																					
Y01SL11	0 =>																					
Y01SL01	0 =>																					
Y01SL03	0 =>																					
Y01SL04	0 =>																					
Tractor number:																						
Y01TN	1 =>																					
Available tractor hours:																						
Y01ST05	0 =>																					
Y01ST07	0 =>																					
Y01ST08	0 =>																					
Y01ST09	0 =>																					
Y01ST10	0 =>																					
Y01ST11	0 =>																					
Y01ST01	0 =>																					
Y01ST03	0 =>																					
Y01ST04	0 =>																					
Tractor requirements:																						
Y01TR05	0 =>	-1.00																				
Y01TR07	0 =>		-1.00																			
Y01TR08	0 =>			-1.00																		
Y01TR09	0 =>				-1.00																	
Y01TR10	0 =>					-1.00																
Y01TR11	0 =>						-1.00															
Y01TR01	0 =>							-1.00														
Y01TR03	0 =>								-1.00													
Y01TR04	0 =>									-1.00												
Harvester requirements:																						
Y01HR09	0 =>										-1.00											
Y01HR03	0 =>											-1.00										
Y01HR04	0 =>												-1.00									
Maintenace costs:																						
(family consumption)																						
Y01fc	1 =																					
(discretionary cons.)																						
Y01dc04	0 =>																					
(overhead costs)																						
Y01oc	1 =																					

Sub-matrix A3.5

ACTIVITIES		Hired mach. Tractor									Harvester			Capital Transfer								
		HT0105	HT0107	HT0108	HT0109	HT0110	HT0111	HT0101	HT0103	HT0104	HH0109	HH0103	HH0104	CT0105	CT0106	CT0107	CT0108	CT0109	CT0110	CT0111	CT0112	CT0101
CONSTRAINTS																						
Machine variable costs:																						
Y01MVC05	0 =>	1.27																				
Y01MVC07	0 =>		1.27																			
Y01MVC08	0 =>			1.27																		
Y01MVC09	0 =>				1.27						3.83											
Y01MVC10	0 =>					1.27																
Y01MVC11	0 =>						1.27															
Y01MVC01	0 =>							1.27														
Y01MVC03	0 =>								1.27			3.83										
Y01MVC04	0 =>									1.27			3.83									
Costs of direct inputs:																						
Y01CDI05	0 =>																					
Y01CDI07	0 =>																					
Y01CDI08	0 =>																					
Y01CDI09	0 =>																					
Y01CDI10	0 =>																					
Y01CDI11	0 =>																					
Y01CDI01	0 =>																					
Y01CDI03	0 =>																					
Y01CDI04	0 =>																					
Asset evaluation:																						
Y01AE04	0 =>																					
Working capital:																						
Y01WK05	2500 =>													1.00								
Y01WK06	0 =>													-1.01	1.00							
Y01WK07	0 =>														-1.01	1.00						
Y01WK08	0 =>															-1.01	1.00					
Y01WK09	0 =>																-1.01	1.00				
Y01WK10	0 =>																	-1.01	1.00			
Y01WK11	0 =>																		-1.01	1.00		
Y01WK12	0 =>																			-1.01	1.00	
Y01WK01	0 =>																				-1.01	1.00
Y01WK02	0 =>																					-1.01
Y01WK03	0 =>																					
Y01WK04	0 =>																					
Overdraft (short term):																						
Y01OD05	0 =>																					
Y01OD07	0 =>																					
Y01OD09	0 =>																					
Y01OD10	0 =>																					
Y01OD11	0 =>																					
Y01OD02	0 =>																					
Long term investments: (plan A)																						
Y01IA05	0 =>																					
Y01IA06	0 =>																					
Y01IA07	0 =>																					
Y01IA08	0 =>																					
Y01IA09	0 =>																					
Y01IA10	0 =>																					
Y01IA11	0 =>																					
Y01IA12	0 =>																					
Y01IA01	0 =>																					

			Transfer								Credit											Short term (machinery costs)		
	ACTIVITIES	Capital	CT0102	CT0103	Commercial	CC0105	CC0106	CC0107	CC0108	CC0109	CC0110	CC0111	CC0112	CC0101	CC0102	CC0103	CC0104	Ag. credit	MVC0105	MVC0107	MVC0108	MVC0109	MVC0110	MVC0111	MVC0101
CONSTRAINTS																									
Machine variable costs:																									
Y01MVC05	0 =>																		-1.00						
Y01MVC07	0 =>																			-1.00					
Y01MVC08	0 =>																				-1.00				
Y01MVC09	0 =>																					-1.00			
Y01MVC10	0 =>																						-1.00		
Y01MVC11	0 =>																							-1.00	
Y01MVC01	0 =>																								-1.00
Y01MVC03	0 =>																								
Y01MVC04	0 =>																								
Costs of direct inputs:																									
Y01CDI05	0 =>																								
Y01CDI07	0 =>																								
Y01CDI08	0 =>																								
Y01CDI09	0 =>																								
Y01CDI10	0 =>																								
Y01CDI11	0 =>																								
Y01CDI01	0 =>																								
Y01CDI03	0 =>																								
Y01CDI04	0 =>																								
Asset evaluation:																									
Y01AE04	0 =>																								
Working capital:																									
Y01WK05	2500 =>					-1.00													1.00						
Y01WK06	0 =>					1.02	-1.00																		
Y01WK07	0 =>						1.02	-1.00												1.00					
Y01WK08	0 =>							1.02	-1.00												1.00				
Y01WK09	0 =>								1.02	-1.00												1.00			
Y01WK10	0 =>									1.02	-1.00												1.00		
Y01WK11	0 =>										1.02	-1.00												1.00	
Y01WK12	0 =>											1.02	-1.00												
Y01WK01	0 =>												1.02	-1.00											1.00
Y01WK02	0 =>		1.00											1.02	-1.00										
Y01WK03	0 =>		-1.01	1.00											1.02	-1.00									
Y01WK04	0 =>			-1.01												1.02	-1.00								
Overdraft (short term):																									
Y01OD05	0 =>																								
Y01OD07	0 =>																								
Y01OD09	0 =>																								
Y01OD10	0 =>																								
Y01OD11	0 =>																								
Y01OD02	0 =>																								
Long term investments: (plan A)																									
Y01IA05	0 =>																								
Y01IA06	0 =>																								
Y01IA07	0 =>																								
Y01IA08	0 =>																								
Y01IA09	0 =>																								
Y01IA10	0 =>																								
Y01IA11	0 =>																								
Y01IA12	0 =>																								
Y01IA01	0 =>																								

			Transfer			Credit													Short term (machinery costs)						
	ACTIVITIES	Capital	CT0102	CT0103	Commercial	CC0105	CC0106	CC0107	CC0108	CC0109	CC0110	CC0111	CC0112	CC0101	CC0102	CC0103	CC0104	Ag.credit	MVC0105	MVC0107	MVC0108	MVC0109	MVC0110	MVC0111	MVC0101
CONSTRAINTS																									
Long term investments: (plan A)																									
Y01IA02	0 =>																								
Y01IA03	0 =>																								
Y01IA04	0 =>																								
Long term investments: (plan B)																									
Y01IB05	0 =>																								
Y01IB06	0 =>																								
Y01IB07	0 =>																								
Y01IB08	0 =>																								
Y01IB09	0 =>																								
Y01IB10	0 =>																								
Y01IB11	0 =>																								
Y01IB12	0 =>																								
Y01IB01	0 =>																								
Y01IB02	0 =>																								
Y01IB03	0 =>																								
Y01IB04	0 =>																								
(plan C)																									
Y01IC05	0 =>																								
Y01IC06	0 =>																								
Y01IC07	0 =>																								
Y01IC08	0 =>																								
Y01IC09	0 =>																								
Y01IC10	0 =>																								
Y01IC11	0 =>																								
Y01IC12	0 =>																								
Y01IC01	0 =>																								
Y01IC02	0 =>																								
Y01IC03	0 =>																								
Y01IC04	0 =>																								
Market capital:																									
Y01MK05	1000 =>					1.00																			
Y01MK06	1000 =>						1.00																		
Y01MK07	1000 =>							1.00																	
Y01MK08	1000 =>								1.00																
Y01MK09	1000 =>									1.00															
Y01MK10	1000 =>										1.00														
Y01MK11	1000 =>											1.00													
Y01MK12	1000 =>												1.00												
Y01MK01	1000 =>													1.00											
Y01MK02	1000 =>														1.00										
Y01MK03	1000 =>															1.00									
Y01MK04	1000 =>																1.00								
Production for sale: (irrig. supplied)																									
Y01W09	0 =>																								
(no irrigation)																									
Y01R03	0 =>																								
Y01R04	0 =>																								
Y01S04	0 =>																								
Y02M05	0 =>																								

			Transfer			Credit													Short term (machinery costs)						
CONSTRAINTS	ACTIVITIES	Capital	CT0102	CT0103	Commercial	CC0105	CC0106	CC0107	CC0108	CC0109	CC0110	CC0111	CC0112	CC0201	CC0202	CC0203	CC0204	Ag. credit	MVC0105	MVC0107	MVC0108	MVC0109	MVC0110	MVC0111	MVC0101
Income ties:																									
Y01IT09	0 =>																								
Y01IT10	0 =>																								
Y01IT11	0 =>																								
Y01IT12	0 =>																								
Y01IT01	0 =>																								
Y01IT02	0 =>																								
Y01IT03	0 =>																								
Y01IT04	0 =>																								
Pos-tax income:																									
Y01PTI	0 =																	1.02							
Income allocation:																									
Y01Y1	0 =																								
Used soil ties:																									
(no irrigated soil)																									
T1LVA0t	0 =>																								
T1LVE0t	0 =>																								
(irrigate soil)																									
T1LVE2t	0 =>																								
T1LHi2t	0 =>																								
Rotation ties:																									
T1cLVA0	0 =>																								
T1lLVA0	0 =>																								
T1cLVE0	0 =>																								
T1lLVE0	0 =>																								
T1cLHi0	0 =>																								
T1lLHi0	0 =>																								
T1lLVE2	0 =>																								
T1lLHi2	0 =>																								
Irrigation system ties:																									
T1IS1t	0 =>																								
T1IS2t	0 =>																								
Tractor aquisition tie:																									
T1ST1t	0 =>																								
Overdraft bills:																									
T1Ob05t	0 =>																								
T1Ob06t	0 =>																								
Mortgage:																									
T1MOA	0 =>																								
T1MOB	0 =>																								
T1MOC	0 =>																								
Asset value:																									
T1Av	0 =>																								
Production carry-over:																									
T1Rco	0 =>																								
T1Sco	0 =>																								
Farm business cash:																									
T1Fbc	0 =>																								
Farm business deficit:																									
T1Fbd	0 =>																								

Sub-matrix A3.7

	ACTIVITIES		....	....		........Short term (direct input costs)........										........Plan A........									
		Ag. credit	MVC0103	MVC0104	Ag. credit	CDI0105	CDI0107	CDI0108	CDI0109	CDI0110	CDI0111	CDI0101	CDI0103	CDI0104	Investment	IA0105	IA0106	IA0107	IA0108	IA0109	IA0110	IA0111	IA0112	IA0101	IA0102
CONSTRAINTS																									
Machine variable costs:																									
Y01MVC05	0 =>																								
Y01MVC07	0 =>																								
Y01MVC08	0 =>																								
Y01MVC09	0 =>																								
Y01MVC10	0 =>																								
Y01MVC11	0 =>																								
Y01MVC01	0 =>																								
Y01MVC03	0 =>		-1.00																						
Y01MVC04	0 =>			-1.00																					
Costs of direct inputs:																									
Y01CDI05	0 =>					-1.00																			
Y01CDI07	0 =>						-1.00																		
Y01CDI08	0 =>							-1.00																	
Y01CDI09	0 =>								-1.00																
Y01CDI10	0 =>									-1.00															
Y01CDI11	0 =>										-1.00														
Y01CDI01	0 =>											-1.00													
Y01CDI03	0 =>												-1.00												
Y01CDI04	0 =>													-1.00											
Asset evaluation:																									
Y01AE04	0 =>																								
Working capital:																									
Y01WK05	2500 =>					1.00																			
Y01WK06	0 =>																								
Y01WK07	0 =>						1.00																		
Y01WK08	0 =>							1.00																	
Y01WK09	0 =>								1.00																
Y01WK10	0 =>									1.00															
Y01WK11	0 =>										1.00														
Y01WK12	0 =>																								
Y01WK01	0 =>											1.00													
Y01WK02	0 =>																								
Y01WK03	0 =>		1.00										1.00												
Y01WK04	0 =>			1.00										1.00											
Overdraft (short term):																									
Y01OD05	0 =>																								
Y01OD07	0 =>																								
Y01OD09	0 =>																								
Y01OD10	0 =>																								
Y01OD11	0 =>																								
Y01OD02	0 =>																								
Long term investments: (plan A)																									
Y01IA05	0 =>															-1.00									
Y01IA06	0 =>															0.97	-1.00								
Y01IA07	0 =>																0.97	-1.00							
Y01IA08	0 =>																	0.97	-1.00						
Y01IA09	0 =>																		0.97	-1.00					
Y01IA10	0 =>																			0.97	-1.00				
Y01IA11	0 =>																				0.97	-1.00			
Y01IA12	0 =>																					0.97	-1.00		
Y01IA01	0 =>																						0.97	-1.00	

ACTIVITIES		Ag.credit	.... MVC0103	.... MVC0104	Ag.credit	........Short term (direct input costs)........ CDI0105	CDI0107	CDI0108	CDI0109	CDI0110	CDI0111	CDI0101	CDI0103	CDI0104	Investmet	........Plan A........ IA0105	IA0106	IA0107	IA0108	IA0109	IA0110	IA0111	IA0112	IA0101	IA0102
CONSTRAINTS																									
Long term investments: (plan A)																									
Y01IA02	0 =>																							0.97	-1.00
Y01IA03	0 =>																								0.97
Y01IA04	0 =>																								
Long term investments: (plan B)																									
Y01IB05	0 =>																								
Y01IB06	0 =>																								
Y01IB07	0 =>																								
Y01IB08	0 =>																								
Y01IB09	0 =>																								
Y01IB10	0 =>																								
Y01IB11	0 =>																								
Y01IB12	0 =>																								
Y01IB01	0 =>																								
Y01IB02	0 =>																								
Y01IB03	0 =>																								
Y01IB04	0 =>																								
(plan C)																									
Y01IC05	0 =>																								
Y01IC06	0 =>																								
Y01IC07	0 =>																								
Y01IC08	0 =>																								
Y01IC09	0 =>																								
Y01IC10	0 =>																								
Y01IC11	0 =>																								
Y01IC12	0 =>																								
Y01IC01	0 =>																								
Y01IC02	0 =>																								
Y01IC03	0 =>																								
Y01IC04	0 =>																								
Market capital:																									
Y01MK05	1000 =>																								
Y01MK06	1000 =>																								
Y01MK07	1000 =>																								
Y01MK08	1000 =>																								
Y01MK09	1000 =>																								
Y01MK10	1000 =>																								
Y01MK11	1000 =>																								
Y01MK12	1000 =>																								
Y01MK01	1000 =>																								
Y01MK02	1000 =>																								
Y01MK03	1000 =>																								
Y01MK04	1000 =>																								
Production for sale: (irrig. supplied)																									
Y01W09	0 =>																								
(no irrigation)																									
Y01R03	0 =>																								
Y01R04	0 =>																								
Y01S04	0 =>																								
Y02M05	0 =>																								

Sub-matrix A4.8

ACTIVITIES		Investmet	IA0103 (Plan A)	IA0104 (Plan A)	Agr.credit Invst.	IB0105 (Plan B)	IB0106	IB0107	IB0108	IB0109	IB0110	IB0111	IB0112	IB0101	IB0102	IB0103	IB0104	IC0105 (Plan C)	IC0106	IC0107	IC0108	IC0109	IC0110	IC0111
CONSTRAINTS																								
Long term investments: (plan A)																								
Y01IA02	0 =>																							
Y01IA03	0 =>		-1.00																					
Y01IA04	0 =>		0.97	-1.00																				
Long term investments: (plan B)																								
Y01IB05	0 =>					-1.00																		
Y01IB06	0 =>					1.001	-1.00																	
Y01IB07	0 =>						1.001	-1.00																
Y01IB08	0 =>							1.001	-1.00															
Y01IB09	0 =>								1.001	-1.00														
Y01IB10	0 =>									1.001	-1.00													
Y01IB11	0 =>										1.001	-1.00												
Y01IB12	0 =>											1.001	-1.00											
Y01IB01	0 =>												1.001	-1.00										
Y01IB02	0 =>													1.001	-1.00									
Y01IB03	0 =>														1.001	-1.00								
Y01IB04	0 =>															1.001	-1.00							
(plan C)																								
Y01IC05	0 =>																	-1.00						
Y01IC06	0 =>																	1.003	-1.00					
Y01IC07	0 =>																		1.003	-1.00				
Y01IC08	0 =>																			1.003	-1.00			
Y01IC09	0 =>																				1.003	-1.00		
Y01IC10	0 =>																					1.003	-1.00	
Y01IC11	0 =>																						1.003	-1.00
Y01IC12	0 =>																							1.003
Y01IC01	0 =>																							
Y01IC02	0 =>																							
Y01IC03	0 =>																							
Y01IC04	0 =>																							
Market capital:																								
Y01MK05	1000 =>																							
Y01MK06	1000 =>																							
Y01MK07	1000 =>																							
Y01MK08	1000 =>																							
Y01MK09	1000 =>																							
Y01MK10	1000 =>																							
Y01MK11	1000 =>																							
Y01MK12	1000 =>																							
Y01MK01	1000 =>																							
Y01MK02	1000 =>																							
Y01MK03	1000 =>																							
Y01MK04	1000 =>																							
Production for sale: (irrig. supplied)																								
Y01W09	0 =>																							
(no irrigation)																								
Y01R03	0 =>																							
Y01R04	0 =>																							
Y01S04	0 =>																							
Y02M05	0 =>																							

Sub-matrix A5.8

			Plan A			Plan B												Plan C						
	ACTIVITIES	Investment	IA0103	IA0104	Agr.credit Invest.	IB0105	IB0106	IB0107	IB0108	IB0109	IB0110	IB0111	IB0112	IB0101	IB0102	IB0103	IB0104	IC0105	IC0106	IC0107	IC0108	IC0109	IC0110	IC0111
CONSTRAINTS																								
Income ties:																								
Y01IT09	0 =>																							
Y01IT10	0 =>																							
Y01IT11	0 =>																							
Y01IT12	0 =>																							
Y01IT01	0 =>																							
Y01IT02	0 =>																							
Y01IT03	0 =>																							
Y01IT04	0 =>																							
Pos-tax income:																								
Y01PTI	0 =																							
Income allocation:																								
Y01Y1	0 =																							
Used soil ties:																								
(no irrigated soil)																								
T1LVA0t	0 =>																							
T1LVE0t	0 =>																							
(irrigate soil)																								
T1LVE2t	0 =>																							
T1LHi2t	0 =>																							
Rotation ties:																								
T1cLVA0	0 =>																							
T1lLVA0	0 =>																							
T1cLVE0	0 =>																							
T1lLVE0	0 =>																							
T1cLHi0	0 =>																							
T1lLHi0	0 =>																							
T1lLVE2	0 =>																							
T1lLHi2	0 =>																							
Irrigation system ties:																								
T1IS1t	0 =>																							
T1IS2t	0 =>																							
Tractor aquisition tie:																								
T1ST1t	0 =>																							
Overdraft bills:																								
T1Ob05t	0 =>																							
T1Ob06t	0 =>																							
Mortgage:																								
T1MOA	0 =>			0.97																				
T1MOB	0 =>																1.001							
T1MOC	0 =>																							
Asset value:																								
T1Av	0 =>																							
Production carry-over:																								
T1Rco	0 =>																							
T1Sco	0 =>																							
Farm business cash:																								
T1Fbc	0 =>																							
Farm business deficit:																								
T1Fbd	0 =>																							

Sub-matrix A1.9

ACTIVITIES		Agr. credit	Invest.				Transfers plan A													Transfers plan B				
			IC0102	IC0103	IC0104	Capital Soils	Li0105A	NP0105A	CP0110A	CK0110A	Cm0110A	CP0105A	CK0105A	Cm0105A	ca0105A	cs0105A	ce0105A	Assets	IA0105A	Li0105B	NP0105B	CP0110B	CK0110B	Cm0110B
CONSTRAINTS																								
Soil classes (up land):																								
Y01LVAi0	20 =>																							
Y01LVEi0	45 =>																							
Irrigatable soils:																								
Y01LVEi2	15 =>																							
Y01LVEi1	0 =>																							
Y01LHii2	20 =>																							
Y01LHii1	0 =>																							
Irrigation permission:																								
Y01ir1	0 =>																							
Y01ir2	0 =>																							
Water supply:																								
Y01ws1i1	0 =>																							
Y01ws1i2	0 =>																							
Y01ws2i1	0 =>																							
Y01ws2i2	0 =>																							
Soil preparation inv.:																								
Y01Lim05	0 =>						-1.00													-1.00				
Y01NtP05	0 =>							-1.00													-1.00			
Y01ChP10	0 =>								-1.00													-1.00		
Y01ChK10	0 =>									-1.00													-1.00	
Y01CMi10	0 =>										-1.00													-1.00
Y01ChP05	0 =>											-1.00												
Y01ChK05	0 =>												-1.00											
Y01CMi05	0 =>													-1.00										
Y01CCa05	0 =>														-1.00									
Y01CSC05	0 =>															-1.00								
Y01CCe05	0 =>																-1.00							
Soil use ties:																								
Y01LVA0t	0 =>																							
Y01LVE0t	0 =>																							
Y01LHi0t	0 =>																							
Y01LVE1t	0 =>																							
Y01LHi1t	0 =>																							
Y01LVE2t	0 =>																							
Y01LHi2t	0 =>																							
Investments in assets:																								
Y01LT05a	0 =>																		-1.00					
Y01LT05b	0 =>																							
Y01LT05c	0 =>																							
Family labour:																								
Y01FL05	200 =>																							
Y01FL06	200 =>																							
Y01FL07	200 =>																							
Y01FL08	200 =>																							
Y01FL09	200 =>																							
Y01FL10	200 =>																							
Y01FL11	200 =>																							
Y01FL12	100 =>																							
Y01FL01	200 =>																							
Y01FL02	200 =>																							
Y01FL03	200 =>																							
Y01FL04	200 =>																							

ACTIVITIES		Agr.credit	Invest. IC0102	Invest. IC0103	Invest. IC0104	Soils Capital	Transfers plan A Li0105A	NP0105A	CP0110A	CK0110A	Cm0110A	CP0105A	CK0105A	Cm0105A	ca0105A	sc0105A	ce0105A	Assets	AI0105A	Transfers plan B Li0105B	NP0105B	CP0110B	CK0110B	Cm0110B
CONSTRAINTS																								
Machine variable costs:																								
Y01MVC05	0 =>																							
Y01MVC07	0 =>																							
Y01MVC08	0 =>																							
Y01MVC09	0 =>																							
Y01MVC10	0 =>																							
Y01MVC11	0 =>																							
Y01MVC01	0 =>																							
Y01MVC03	0 =>																							
Y01MVC04	0 =>																							
Costs of direct inputs:																								
Y01CDI05	0 =>																							
Y01CDI07	0 =>																							
Y01CDI08	0 =>																							
Y01CDI09	0 =>																							
Y01CDI10	0 =>																							
Y01CDI11	0 =>																							
Y01CDI01	0 =>																							
Y01CDI03	0 =>																							
Y01CDI04	0 =>																							
Asset evaluation:																								
Y01AE04	0 =>																							
Working capital:																								
Y01WK05	2500 =>																							
Y01WK06	0 =>																							
Y01WK07	0 =>																							
Y01WK08	0 =>																							
Y01WK09	0 =>																							
Y01WK10	0 =>																							
Y01WK11	0 =>																							
Y01WK12	0 =>																							
Y01WK01	0 =>																							
Y01WK02	0 =>																							
Y01WK03	0 =>																							
Y01WK04	0 =>																							
Overdraft (short term):																								
Y01OD05	0 =>																							
Y01OD07	0 =>																							
Y01OD09	0 =>																							
Y01OD10	0 =>																							
Y01OD11	0 =>																							
Y01OD02	0 =>																							
Long term investments: (plan A)																								
Y01IA05	0 =>						1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00		1.00					
Y01IA06	0 =>																							
Y01IA07	0 =>																							
Y01IA08	0 =>																							
Y01IA09	0 =>																							
Y01IA10	0 =>								1.00	1.00	1.00													
Y01IA11	0 =>																							
Y01IA12	0 =>																							
Y01IA01	0 =>																							

Sub-matrix A4.9

ACTIVITIES		Agr.credit Invest. IC0102	IC0103	IC0104	Capital Soils	Transfers plan A: Li0105A	NP0105A	CP0110A	CK0110A	Cm0110A	CP0105A
CONSTRAINTS											
Long term investments: (plan A)											
Y01IA02	0 =>										
Y01IA03	0 =>										
Y01IA04	0 =>										
Long term investments: (plan B)											
Y01IB05	0 =>										
Y01IB06	0 =>										
Y01IB07	0 =>										
Y01IB08	0 =>										
Y01IB09	0 =>										
Y01IB10	0 =>										
Y01IB11	0 =>										
Y01IB12	0 =>										
Y01IB01	0 =>										
Y01IB02	0 =>										
Y01IB03	0 =>										
Y01IB04	0 =>										
(plan C)											
Y01IC05	0 =>										
Y01IC06	0 =>										
Y01IC07	0 =>										
Y01IC08	0 =>										
Y01IC09	0 =>										
Y01IC10	0 =>										
Y01IC11	0 =>										
Y01IC12	0 =>										
Y01IC01	0 =>										
Y01IC02	0 =>	-1.00									
Y01IC03	0 =>	1.003	-1.00								
Y01IC04	0 =>		1.003	-1.00							
Market capital:											
Y01MK05	1000 =>										
Y01MK06	1000 =>										
Y01MK07	1000 =>										
Y01MK08	1000 =>										
Y01MK09	1000 =>										
Y01MK10	1000 =>										
Y01MK11	1000 =>										
Y01MK12	1000 =>										
Y01MK01	1000 =>										
Y01MK02	1000 =>										
Y01MK03	1000 =>										
Y01MK04	1000 =>										
Production for sale: (irrig. supplied)											
Y01W09	0 =>										
(no irrigation)											
Y01R03	0 =>										
Y01R04	0 =>										
Y01S04	0 =>										
Y02M05	0 =>										

ACTIVITIES	CK0105A	Cm0105A	ca0105A	sc0105A	ce0105A	Assets	AI0105A	Transfers plan B: Li0105B	NP0105B	CP0110B	CK0110B	Cm0110B
Y01IB05								1.00	1.00			
Y01IB10										1.00	1.00	1.00

All other cells of these columns are empty.

Sub-matrix A5.9

ACTIVITIES		Agr. credit	Invst.			Capital Soils	Transfers plan A													Transfers plan B				
CONSTRAINTS			IC0102	IC0103	IC0104		Li0105A	NP0105A	CP0110A	CK0110A	Cm0110A	CP0105A	CK0105A	Cm0105A	ca0105A	sc0105A	ce0105A	Assets	AI0105A	Li0105B	NP0105B	CP0110B	CK0110B	Cm0110B
Income ties:																								
Y01IT09	0 =>																							
Y01IT10	0 =>																							
Y01IT11	0 =>																							
Y01IT12	0 =>																							
Y01IT01	0 =>																							
Y01IT02	0 =>																							
Y01IT03	0 =>																							
Y01IT04	0 =>																							
Pos-tax income:																								
Y01PTI	0 =																							
Income allocation:																								
Y01Y1	0 =																							
Used soil ties:																								
(no irrigated soil)																								
T1LVA0t	0 =>																							
T1LVE0t	0 =>																							
(irrigate soil)																								
T1LVE2t	0 =>																							
T1LHi2t	0 =>																							
Rotation ties:																								
T1cLVA0	0 =>																							
T1lLVA0	0 =>																							
T1cLVE0	0 =>																							
T1lLVE0	0 =>																							
T1cLHi0	0 =>																							
T1lLHi0	0 =>																							
T1lLVE2	0 =>																							
T1lLHi2	0 =>																							
Irrigation system ties:																								
T1IS1t	0 =>																							
T1IS2t	0 =>																							
Tractor aquisition tie:																								
T1ST1t	0 =>																							
Overdraft bills:																								
T1Ob05t	0 =>																							
T1Ob06t	0 =>																							
Mortgage:																								
T1MOA	0 =>																							
T1MOB	0 =>																							
T1MOC	0 =>				1.003																			
Asset value:																								
T1Av	0 =>																							
Production carry-over:																								
T1Rco	0 =>																							
T1Sco	0 =>																							
Farm business cash:																								
T1Fbc	0 =>																							
Farm business deficit:																								
T1Fbd	0 =>																							

Sub-matrix A1.10

	ACTIVITIES	...Transfers... ...Plan B...				...Transfers... ...plan C...															
		Capital Soils			Assets												Assets	Overdraft			
CONSTRAINTS		ca0105B	sc0105B	ec0105B	AI0105B	Li0105C	NP0105C	CP0110C	CK0110C	Cm0110C	CP0105C	CK0105C	Cm0105C	ca0105C	sc0105C	ec0105C	AI0105C	od0105	od0107	od0109	od0110
Soil classes (up land):																					
Y01LVAi0	20 =>																				
Y01LVEi0	45 =>																				
Irrigatable soils:																					
Y01LVEi2	15 =>																				
Y01LVEi1	0 =>																				
Y01LHii2	20 =>																				
Y01LHii1	0 =>																				
Irrigation permission:																					
Y01ir1	0 =>																				
Y01ir2	0 =>																				
Water supply:																					
Y01ws1i1	0 =>																				
Y01ws1i2	0 =>																				
Y01ws2i1	0 =>																				
Y01ws2i2	0 =>																				
Soil preparation inv.:																					
Y01Lim05	0 =>					-1.00															
Y01NtP05	0 =>						-1.00														
Y01ChP10	0 =>							-1.00													
Y01ChK10	0 =>								-1.00												
Y01CMi10	0 =>									-1.00											
Y01ChP05	0 =>										-1.00										
Y01ChK05	0 =>											-1.00									
Y01CMi05	0 =>												-1.00								
Y01CCa05	0 =>	-1.00												-1.00							
Y01CSC05	0 =>		-1.00												-1.00						
Y01CCe05	0 =>			-1.00												-1.00					
Soil use ties:																					
Y01LVA0t	0 =>																				
Y01LVE0t	0 =>																				
Y01LHi0t	0 =>																				
Y01LVE1t	0 =>																				
Y01LHi1t	0 =>																				
Y01LVE2t	0 =>																				
Y01LHi2t	0 =>																				
Investments in assets:																					
Y01LT05a	0 =>																				
Y01LT05b	0 =>				-1.00																
Y01LT05c	0 =>																-1.00				
Family labour:																					
Y01FL05	200 =>																				
Y01FL06	200 =>																				
Y01FL07	200 =>																				
Y01FL08	200 =>																				
Y01FL09	200 =>																				
Y01FL10	200 =>																				
Y01FL11	200 =>																				
Y01FL12	100 =>																				
Y01FL01	200 =>																				
Y01FL02	200 =>																				
Y01FL03	200 =>																				
Y01FL04	200 =>																				

Sub-matrix A3.10

				Transfers Plan B					Transfers plan C																	
ACTIVITIES		Capital	Soils	ca0105B	cs0105B	ce0105B	Assets	AI0105B	Li0105C	NP0105C	CP0110C	CK0110C	Cm0110C	CP0105C	CK0105C	Cm0105C	ca0105C	cs0105C	ce0105C	Assets	AI0105C	Overdraft	od0105	od0107	od0109	od0110
CONSTRAINTS																										
Machine variable costs:																										
Y01MVC05	0 =>																									
Y01MVC07	0 =>																									
Y01MVC08	0 =>																									
Y01MVC09	0 =>																									
Y01MVC10	0 =>																									
Y01MVC11	0 =>																									
Y01MVC01	0 =>																									
Y01MVC03	0 =>																									
Y01MVC04	0 =>																									
Costs of direct inputs:																										
Y01CDI05	0 =>																									
Y01CDI07	0 =>																									
Y01CDI08	0 =>																									
Y01CDI09	0 =>																									
Y01CDI10	0 =>																									
Y01CDI11	0 =>																									
Y01CDI01	0 =>																									
Y01CDI03	0 =>																									
Y01CDI04	0 =>																									
Asset evaluation:																										
Y01AE04	0 =>																									
Working capital:																										
Y01WK05	2500 =>																						-1.00			
Y01WK06	0 =>																									
Y01WK07	0 =>																							-1.00		
Y01WK08	0 =>																									
Y01WK09	0 =>																								-1.00	
Y01WK10	0 =>																									-1.00
Y01WK11	0 =>																									
Y01WK12	0 =>																									
Y01WK01	0 =>																									
Y01WK02	0 =>																									
Y01WK03	0 =>																									
Y01WK04	0 =>																									
Overdraft (short term):																										
Y01OD05	0 =>																						1.00			
Y01OD07	0 =>																							1.00		
Y01OD09	0 =>																								1.00	
Y01OD10	0 =>																									1.00
Y01OD11	0 =>																									
Y01OD02	0 =>																									
Long term investments: (plan A)																										
Y01IA05	0 =>																									
Y01IA06	0 =>																									
Y01IA07	0 =>																									
Y01IA08	0 =>																									
Y01IA09	0 =>																									
Y01IA10	0 =>																									
Y01IA11	0 =>																									
Y01IA12	0 =>																									
Y01IA01	0 =>																									

Sub-matrix A4.10

ACTIVITIES		Capital	Soils	B5010ac	B5010cs	B5010ec	Assets	B5010IA	C5010iL	C5010PN	C0110PC	C0110KC	C0110mC	C5010PC	C5010KC	C5010mC	C5010ac	C5010cs	C5010ec	Assets	C5010IA	Overdraft	5010do	7010do	9010do	0110do
				Transfers Plan B					Transfers plan C																	
CONSTRAINTS																										
Long term investments: (plan A)																										
Y01IA02	0 =>																									
Y01IA03	0 =>																									
Y01IA04	0 =>																									
Long term investments: (plan B)																										
Y01IB05	0 =>			1.00	1.00	1.00		1.00																		
Y01IB06	0 =>																									
Y01IB07	0 =>																									
Y01IB08	0 =>																									
Y01IB09	0 =>																									
Y01IB10	0 =>																									
Y01IB11	0 =>																									
Y01IB12	0 =>																									
Y01IB01	0 =>																									
Y01IB02	0 =>																									
Y01IB03	0 =>																									
Y01IB04	0 =>																									
(plan C)																										
Y01IC05	0 =>								1.00	1.00				1.00	1.00	1.00	1.00	1.00	1.00		1.00					
Y01IC06	0 =>																									
Y01IC07	0 =>																									
Y01IC08	0 =>																									
Y01IC09	0 =>																									
Y01IC10	0 =>										1.00	1.00	1.00													
Y01IC11	0 =>																									
Y01IC12	0 =>																									
Y01IC01	0 =>																									
Y01IC02	0 =>																									
Y01IC03	0 =>																									
Y01IC04	0 =>																									
Market capital:																										
Y01MK05	1000 =>																									
Y01MK06	1000 =>																									
Y01MK07	1000 =>																									
Y01MK08	1000 =>																									
Y01MK09	1000 =>																									
Y01MK10	1000 =>																									
Y01MK11	1000 =>																									
Y01MK12	1000 =>																									
Y01MK01	1000 =>																									
Y01MK02	1000 =>																									
Y01MK03	1000 =>																									
Y01MK04	1000 =>																									
Production for sale: (irrig. supplied)																										
Y01W09	0 =>																									
(no irrigation)																										
Y01R03	0 =>																									
Y01R04	0 =>																									
Y01S04	0 =>																									
Y02M05	0 =>																									

Sub-matrix A5.10

	ACTIVITIES	Capital	Soils	Transfers Plan B					Transfers plan C																
				ca0105B	cs0105B	ce0105B	Assets	AI0105B	Li0105C	NP0105C	CP0110C	CK0110C	Cm0110C	CP0105C	CK0105C	Cm0105C	ca0105C	cs0105C	ce0105C	Assets	AI0105C	Overdraft	od0105	od0107	od0109	od0110
CONSTRAINTS																										
Income ties:																										
Y01IT09	0 =>																									
Y01IT10	0 =>																									
Y01IT11	0 =>																									
Y01IT12	0 =>																									
Y01IT01	0 =>																									
Y01IT02	0 =>																									
Y01IT03	0 =>																									
Y01IT04	0 =>																									
Pos-tax income:																										
Y01PTI	0 =																									
Income allocation:																										
Y01Y1	0 =																									
Used soil ties:																										
(no irrigated soil)																										
T1LVA0t	0 =>																									
T1LVE0t	0 =>																									
(irrigate soil)																										
T1LVE2t	0 =>																									
T1LHi2t	0 =>																									
Rotation ties:																										
T1cLVA0	0 =>																									
T1lLVA0	0 =>																									
T1cLVE0	0 =>																									
T1lLVE0	0 =>																									
T1cLHi0	0 =>																									
T1lLHi0	0 =>																									
T1lLVE2	0 =>																									
T1lLHi2	0 =>																									
Irrigation system ties:																										
T1IS1t	0 =>																									
T1IS2t	0 =>																									
Tractor aquisition tie:																										
T1ST1t	0 =>																									
Overdraft bills:																										
T1Ob05t	0 =>																							0.784717	0.817073	0.850763	0.868113
T1Ob06t	0 =>																									
Mortgage:																										
T1MOA	0 =>																									
T1MOB	0 =>																									
T1MOC	0 =>																									
Asset value:																										
T1Av	0 =>																									
Production carry-over:																										
T1Rco	0 =>																									
T1Sco	0 =>																									
Farm business cash:																										
T1Fbc	0 =>																									
Farm business deficit:																										
T1Fbd	0 =>																									

Sub-matrix A2.11

							cons.				cost		Product ...Rice.			Products ... Wheat ...								..soya			Transfers					
ACTIVITIES		Overdraft	od011	od0102	Maintenance	Family	FAM01	Discret.	dc0104	Overhead	OVEC01	Sales	R01s03	R01s04	Sales	W01s09	W01s10	W01s11	W01s12	W01s01	W01s02	W01s03	W01s04	S01s04	Production	InY01	R010304	Carryover	RTY0205	STY0205	Income	In0109
CONSTRAINTS																																
Employed tractor driver:																																
Y01TDPer	0 =>																															
Employed driver hours:																																
Y01EL05	0 =>																															
Y01EL06	0 =>																															
Y01EL07	0 =>																															
Y01EL08	0 =>																															
Y01EL09	0 =>																															
Y01EL10	0 =>																															
Y01EL11	0 =>																															
Y01EL12	0 =>																															
Y01EL01	0 =>																															
Y01EL02	0 =>																															
Y01EL03	0 =>																															
Y01EL04	0 =>																															
Seasonal labour:																																
Y01SL10	0 =>																															
Y01SL11	0 =>																															
Y01SL01	0 =>																															
Y01SL03	0 =>																															
Y01SL04	0 =>																															
Tractor number:																																
Y01TN	1 =>																															
Available tractor hours:																																
Y01ST05	0 =>																															
Y01ST07	0 =>																															
Y01ST08	0 =>																															
Y01ST09	0 =>																															
Y01ST10	0 =>																															
Y01ST11	0 =>																															
Y01ST01	0 =>																															
Y01ST03	0 =>																															
Y01ST04	0 =>																															
Tractor requirements:																																
Y01TR05	0 =>																															
Y01TR07	0 =>																															
Y01TR08	0 =>																															
Y01TR09	0 =>																															
Y01TR10	0 =>																															
Y01TR11	0 =>																															
Y01TR01	0 =>																															
Y01TR03	0 =>																															
Y01TR04	0 =>																															
Harvester requirements:																																
Y01HR09	0 =>																															
Y01HR03	0 =>																															
Y01HR04	0 =>																															
Maintenace costs:																																
(family consumption)																																
Y01fc	1 =						1.00																									
(discretionary cons.)																																
Y01dc04	0 =>								1.00																							
(overhead costs)																																
Y01oc	1 =										1.00																					

				cons.		cost	Product ...Rice.		Products ...Wheat...								..soya			Transfers		
	ACTIVITIES	Overdraft		Maintenance Family	Discret.	Overhead	Sales		Sales									Production		Carryover		Income
CONSTRAINTS		od011	od0102	FAM01	dc0104	OVEC01	R01s03	R01s04	W01s09	W01s10	W01s11	W01s12	W01s01	W01s02	W01s03	W01s04	S01s04	InY01	R010304	RTY0205	STY0205	In0109
Machine variable costs:																						
Y01MVC05	0 =>																					
Y01MVC07	0 =>																					
Y01MVC08	0 =>																					
Y01MVC09	0 =>																					
Y01MVC10	0 =>																					
Y01MVC11	0 =>																					
Y01MVC01	0 =>																					
Y01MVC03	0 =>																					
Y01MVC04	0 =>																					
Costs of direct inputs:																						
Y01CDI05	0 =>																					
Y01CDI07	0 =>																					
Y01CDI08	0 =>																					
Y01CDI09	0 =>																					
Y01CDI10	0 =>																					
Y01CDI11	0 =>																					
Y01CDI01	0 =>																					
Y01CDI03	0 =>																					
Y01CDI04	0 =>																					
Asset evaluation:																						
Y01AE04	0 =>																					
Working capital:																						
Y01WK05	2500 =>			30.42		175.00[1]																
Y01WK06	0 =>			30.42		20.00																
Y01WK07	0 =>			30.42		55.00																
Y01WK08	0 =>			30.42		55.00																
Y01WK09	0 =>			30.42		120.00																-0.975
Y01WK10	0 =>			30.42		300.00																
Y01WK11	0 =>	-1.00		30.42		200.00																
Y01WK12	0 =>			30.42		30.00																
Y01WK01	0 =>			30.42		75.00																
Y01WK02	0 =>		-1.00	30.42		40.00																
Y01WK03	0 =>			30.42		110.00																
Y01WK04	0 =>			30.42		158.00																
Overdraft (short term):																						
Y01OD05	0 =>																					
Y01OD07	0 =>																					
Y01OD09	0 =>																					
Y01OD10	0 =>																					
Y01OD11	0 =>	1.00																				
Y01OD02	0 =>		1.00																			
Long term investments: (plan A)																						
Y01IA05	0 =>																					
Y01IA06	0 =>																					
Y01IA07	0 =>																					
Y01IA08	0 =>																					
Y01IA09	0 =>																					
Y01IA10	0 =>																					
Y01IA11	0 =>																					
Y01IA12	0 =>																					
Y01IA01	0 =>																					

(1) The monthly overhead costs here estimated apply to crop farm sizes up to 200 hectares. For crop farm sizes in the range between 201 and 500 hectares such costs are supposed to increase about 40 percent.

ACTIVITIES		Overdraft	od011	od012	Maintenance family	FAM01	Discret.	dc0104	Overhead	OVEC01	Sales	R01s03	R01s04	Sales	W01s09	W01s10	W01s11	W01s12	W01s01	W01s02	W01s03	W01s04	S01s04	Production	InY01	R010304	Carryover	RTY0205	STY0205	Income	In0109
						cons.				cost		Product ...Rice.			Products ... Wheat								..soya			Transfers					
CONSTRAINTS																															
Long term investments: (plan A)																															
Y01IA02	0 =>																														
Y01IA03	0 =>																														
Y01IA04	0 =>																														
Long term investments: (plan B)																															
Y01IB05	0 =>																														
Y01IB06	0 =>																														
Y01IB07	0 =>																														
Y01IB08	0 =>																														
Y01IB09	0 =>																														
Y01IB10	0 =>																														
Y01IB11	0 =>																														
Y01IB12	0 =>																														
Y01IB01	0 =>																														
Y01IB02	0 =>																														
Y01IB03	0 =>																														
Y01IB04	0 =>																														
(plan C)																															
Y01IC05	0 =>																														
Y01IC06	0 =>																														
Y01IC07	0 =>																														
Y01IC08	0 =>																														
Y01IC09	0 =>																														
Y01IC10	0 =>																														
Y01IC11	0 =>																														
Y01IC12	0 =>																														
Y01IC01	0 =>																														
Y01IC02	0 =>																														
Y01IC03	0 =>																														
Y01IC04	0 =>																														
Market capital:																															
Y01MK05	1000 =>																														
Y01MK06	1000 =>																														
Y01MK07	1000 =>																														
Y01MK08	1000 =>																														
Y01MK09	1000 =>																														
Y01MK10	1000 =>																														
Y01MK11	1000 =>																														
Y01MK12	1000 =>																														
Y01MK01	1000 =>																														
Y01MK02	1000 =>																														
Y01MK03	1000 =>																														
Y01MK04	1000 =>																														
Production for sale: (irrig. supplied)																															
Y01W09	0 =>														1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00									
(no irrigation)																										1.00					
Y01R03	0 =>											1.00														-1.00		1.00			
Y01R04	0 =>												1.00																1.00		
Y01S04	0 =>																						1.00								1.00
Y02M05	0 =>																														

ACTIVITIES		Overdraft		Maintenance cons. Family	Discret.	Overhead cost	Sales Product ...Rice.		Sales Products ..... Wheat								..soya	Production	Carryover Transfers			Income
		od0111	od0102	FAM01	dc0104	OVEC01	R01s03	R01s04	W01s09	W01s10	W01s11	W01s12	W01s01	W01s02	W01s03	W01s04	S01s04	InY01	R010304	RTY0205	STY0205	In0109
CONSTRAINTS																						
Income ties:																						
Y01IT09	0 =>								-1.35													
Y01IT10	0 =>									-1.35												
Y01IT11	0 =>										-1.35											
Y01IT12	0 =>											-1.35										
Y01IT01	0 =>												-1.35									
Y01IT02	0 =>													-1.35								
Y01IT03	0 =>						-1.15								-1.35							
Y01IT04	0 =>							-1.15								-1.35	-1.90					
Pos-tax income:																						
Y01PTI	0 =																					
Income allocation:																						
Y01Y1	0 =																					
Used soil ties:																						
(no irrigated soil)																						
T1LVA0t	0 =>																					
T1LVE0t	0 =>																					
(irrigate soil)																						
T1LVE2t	0 =>																					
T1LHi2t	0 =>																					
Rotation ties:																						
T1cLVA0	0 =>																					
T1lLVA0	0 =>																					
T1cLVE0	0 =>																					
T1lLVE0	0 =>																					
T1cLHi0	0 =>																					
T1lLHi0	0 =>																					
T1lLVE2	0 =>																					
T1lLHi2	0 =>																					
Irrigation system ties:																						
T1IS1t	0 =>																					
T1IS2t	0 =>																					
Tractor aquisition tie:																						
T1ST1t	0 =>																					
Overdraft bills:																						
T1Ob05t	0 =>	0.885843	0.941192																			
T1Ob06t	0 =>																					
Mortgage:																						
T1MOA	0 =>																					
T1MOB	0 =>																					
T1MOC	0 =>																					
Asset value:																						
T1Av	0 =>																					
Production carry-over:																						
T1Rco	0 =>																			-1.00		
T1Sco	0 =>																				-1.00	
Farm business cash:																						
T1Fbc	0 =>																					
Farm business deficit:																						
T1Fbd	0 =>																					

Sub-matrix A2.12

	ACTIVITIES	Income	Transfers In0110	In0111	In0112	In0101	In0102	In0103	In0104	Invested K	INC0104	Asset a. D.	AaD0104	Pos|tax inc	PtY0104	Cash surplus	CS0104	Cash deficit	CD0104
CONSTRAINTS																			
Employed tractor driver:																			
Y01TDPer	0 =>																		
Employed driver hours:																			
Y01EL05	0 =>																		
Y01EL06	0 =>																		
Y01EL07	0 =>																		
Y01EL08	0 =>																		
Y01EL09	0 =>																		
Y01EL10	0 =>																		
Y01EL11	0 =>																		
Y01EL12	0 =>																		
Y01EL01	0 =>																		
Y01EL02	0 =>																		
Y01EL03	0 =>																		
Y01EL04	0 =>																		
Seasonal labour:																			
Y01SL10	0 =>																		
Y01SL11	0 =>																		
Y01SL01	0 =>																		
Y01SL03	0 =>																		
Y01SL04	0 =>																		
Tractor number:																			
Y01TN	1 =>																		
Available tractor hours:																			
Y01ST05	0 =>																		
Y01ST07	0 =>																		
Y01ST08	0 =>																		
Y01ST09	0 =>																		
Y01ST10	0 =>																		
Y01ST11	0 =>																		
Y01ST01	0 =>																		
Y01ST03	0 =>																		
Y01ST04	0 =>																		
Tractor requirements:																			
Y01TR05	0 =>																		
Y01TR07	0 =>																		
Y01TR08	0 =>																		
Y01TR09	0 =>																		
Y01TR10	0 =>																		
Y01TR11	0 =>																		
Y01TR01	0 =>																		
Y01TR03	0 =>																		
Y01TR04	0 =>																		
Harvester requirements:																			
Y01HR09	0 =>																		
Y01HR03	0 =>																		
Y01HR04	0 =>																		
Maintenace costs:																			
(family consumption)																			
Y01fc	1 =																		
(discretionary cons.)																			
Y01dc04	0 =>																-0.30		
(overhead costs)																			
Y01oc	1 =																		

Sub-matrix A3.12

		Transfers																	
	ACTIVITIES	Income	In0110	In0111	In0112	In0101	In0102	In0103	In0104	Invested K	INC0104	Asset a.D.	AaD0104	Pos|tax inc	PtY0104	Cash surplus	CS0104	Cash deficit	CD0104
CONSTRAINTS																			
Machine variable costs:																			
Y01MVC05	0 =>																		
Y01MVC07	0 =>																		
Y01MVC08	0 =>																		
Y01MVC09	0 =>																		
Y01MVC10	0 =>																		
Y01MVC11	0 =>																		
Y01MVC01	0 =>																		
Y01MVC03	0 =>																		
Y01MVC04	0 =>																		
Costs of direct inputs:																			
Y01CDI05	0 =>																		
Y01CDI07	0 =>																		
Y01CDI08	0 =>																		
Y01CDI09	0 =>																		
Y01CDI10	0 =>																		
Y01CDI11	0 =>																		
Y01CDI01	0 =>																		
Y01CDI03	0 =>																		
Y01CDI04	0 =>																		
Asset evaluation:																			
Y01AE04	0 =>												1.00						
Working capital:																			
Y01WK05	2500 =>																		
Y01WK06	0 =>																		
Y01WK07	0 =>																		
Y01WK08	0 =>																		
Y01WK09	0 =>																		
Y01WK10	0 =>		-0.975																
Y01WK11	0 =>			-0.975															
Y01WK12	0 =>				-0.975														
Y01WK01	0 =>					-0.975													
Y01WK02	0 =>						-0.975												
Y01WK03	0 =>							-0.975											
Y01WK04	0 =>								-0.975		1.00								
Overdraft (short term):																			
Y01OD05	0 =>																		
Y01OD07	0 =>																		
Y01OD09	0 =>																		
Y01OD10	0 =>																		
Y01OD11	0 =>																		
Y01OD02	0 =>																		
Long term investments: (plan A)																			
Y01IA05	0 =>																		
Y01IA06	0 =>																		
Y01IA07	0 =>																		
Y01IA08	0 =>																		
Y01IA09	0 =>																		
Y01IA10	0 =>																		
Y01IA11	0 =>																		
Y01IA12	0 =>																		
Y01IA01	0 =>																		

Sub-matrix A4.12

ACTIVITIES		Income	In0110	In0111	In0112	In0101	In0102	In0103	In0104	Invested K	INC0104	Asset a.D.	AaD0104	Pos|tax inc	PtY0104	Cash surplus	CaS0104	Cash deficit	CaD0104
CONSTRAINTS																			
Long term investments: (plan A)																			
Y01IA02	0 =>																		
Y01IA03	0 =>																		
Y01IA04	0 =>																		
Long term investments: (plan B)																			
Y01IB05	0 =>																		
Y01IB06	0 =>																		
Y01IB07	0 =>																		
Y01IB08	0 =>																		
Y01IB09	0 =>																		
Y01IB10	0 =>																		
Y01IB11	0 =>																		
Y01IB12	0 =>																		
Y01IB01	0 =>																		
Y01IB02	0 =>																		
Y01IB03	0 =>																		
Y01IB04	0 =>																		
(plan C)																			
Y01IC05	0 =>																		
Y01IC06	0 =>																		
Y01IC07	0 =>																		
Y01IC08	0 =>																		
Y01IC09	0 =>																		
Y01IC10	0 =>																		
Y01IC11	0 =>																		
Y01IC12	0 =>																		
Y01IC01	0 =>																		
Y01IC02	0 =>																		
Y01IC03	0 =>																		
Y01IC04	0 =>																		
Market capital:																			
Y01MK05	1000 =>																		
Y01MK06	1000 =>																		
Y01MK07	1000 =>																		
Y01MK08	1000 =>																		
Y01MK09	1000 =>																		
Y01MK10	1000 =>																		
Y01MK11	1000 =>																		
Y01MK12	1000 =>																		
Y01MK01	1000 =>																		
Y01MK02	1000 =>																		
Y01MK03	1000 =>																		
Y01MK04	1000 =>																		
Production for sale: (irrig. supplied)																			
Y01W09	0 =>																		
(no irrigation)																			
Y01R03	0 =>																		
Y01R04	0 =>																		
Y01S04	0 =>																		
Y02M05	0 =>		1.00																

Transfers: In0110, In0111, In0112, In0101, In0102, In0103, In0104

Sub-matrix A5.12

CONSTRAINTS	ACTIVITIES	Transfers																	
		Income	In0110	In0111	In0112	In0101	In0102	In0103	In0104	Invested K	INC0104	Asset a. D.	AaD0104	Pos-tax inc	PtY0104	Cash surplus	CS0104	Cash deficit	CD0104
Income ties:				1.00															
Y01IT09	0 =>				1.00														
Y01IT10	0 =>					1.00													
Y01IT11	0 =>						1.00												
Y01IT12	0 =>							1.00											
Y01IT01	0 =>								1.00										
Y01IT02	0 =>																		
Y01IT03	0 =>																		
Y01IT04	0 =>																		
Pos-tax income:																			
Y01PTI	0 =										-1.01				1.00				-1.00
Income allocation:																			
Y01Y1	0 =														-1.00		1.00		
Used soil ties:																			
(no irrigated soil)																			
T1LVA0t	0 =>																		
T1LVE0t	0 =>																		
(irrigate soil)																			
T1LVE2t	0 =>																		
T1LHi2t	0 =>																		
Rotation ties:																			
T1cLVA0	0 =>																		
T1lLVA0	0 =>																		
T1cLVE0	0 =>																		
T1lLVE0	0 =>																		
T1cLHi0	0 =>																		
T1lLHi0	0 =>																		
T1lLVE2	0 =>																		
T1lLHi2	0 =>																		
Irrigation system ties:																			
T1IS1t	0 =>																		
T1IS2t	0 =>																		
Tractor aquisition tie:																			
T1ST1t	0 =>																		
Overdraft bills:																			
T1Ob05t	0 =>																		
T1Ob06t	0 =>																		
Mortgage:																			
T1MOA	0 =>																		
T1MOB	0 =>																		
T1MOC	0 =>																		
Asset value:																			
T1Av	0 =>												-0.90						
Production carry-over:																			
T1Rco	0 =>																		
T1Sco	0 =>																		
Farm business cash:																			
T1Fbc	0 =>																-0.70		
Farm business deficit:																			
T1Fbd	0 =>																		1.02

CONSTRAINTS	ACTIVITIES	TRANSFERS Soil inf. I01LVAi0	I01LVEi0	I01LVEi2	I01LHii2	Rotation Ir0101	Ir0102	Ir0103	Ir0104	Ir0105	Ir0106	Ir0107	Ir0108	Irrigation Iis01s1	Iis01s2	Tractors Ist01t1	Overdraft Iob0205	Iob0206	Mortgage Im01a02	Im01b02	Im01c02	Asset Ia0104A	Production R01Y0205	S01Y0205	Farm cash I01fc	Farm defic I01fd
Income ties:																										
Y01IT09	0 =>																									
Y01IT10	0 =>																									
Y01IT11	0 =>																									
Y01IT12	0 =>																									
Y01IT01	0 =>																									
Y01IT02	0 =>																									
Y01IT03	0 =>																									
Y01IT04	0 =>																									
Pos-tax income:																										
Y01PTI	0 =																									
Income allocation:																										
Y01Y1	0 =																									
Used soil ties:																										
(no irrigated soil)																										
T1LVA0t	0 =>	-1.00																								
T1LVE0t	0 =>		-1.00																							
(irrigate soil)																										
T1LVE2t	0 =>			-1.00																						
T1LHi2t	0 =>				-1.00																					
Rotation ties:																										
T1cLVA0	0 =>					1.00																				
T1lLVA0	0 =>						1.00																			
T1cLVE0	0 =>							1.00																		
T1lLVE0	0 =>								1.00																	
T1cLHi0	0 =>									1.00																
T1lLHi0	0 =>										1.00															
T1lLVE2	0 =>											1.00														
T1lLHi2	0 =>												1.00													
Irrigation system ties:																										
T1IS1t	0 =>													1.00												
T1IS2t	0 =>														1.00											
Tractor aquisition tie:																										
T1ST1t	0 =>															1.00										
Overdraft bills:																										
T1Ob05t	0 =>																-1.00									
T1Ob06t	0 =>																0.98	-1.00								
Mortgage:																										
T1MOA	0 =>																		-1.00							
T1MOB	0 =>																			-1.00						
T1MOC	0 =>																				-1.00					
Asset value:																										
T1Av	0 =>																					1.00				
Production carry-over:																										
T1Rco	0 =>																						1.00			
T1Sco	0 =>																							1.00		
Farm business cash:																										
T1Fbc	0 =>																								1.00	
Farm business deficit:																										
T1Fbd	0 =>																									-1.00

Sub-matrix TA6_1

ACTIVITIES		Soil inf. I01LVAi0	I01LVEi0	I01LVEi2	I01LHii2	Rotation Ir0101	Ir0102	Ir0103	Ir0104	Ir0105	Ir0106	Ir0107	Ir0108	Irrigation Iis01s1	Iis01s2	Tractor Ist01t1	Overdraft Iob0205	Iob0206	Mortgage Im01a02	Im01b02	Im01c02	Asset Ia0104A	Production R01Y0205	S01Y0205	Farm cash I01fc	Farm defic I01fd
TRANSFERS																										
CONSTRAINTS																										
Soil classes (up land):																										
Y02LVAi0	20 =>	1.00																								
Y02LVEi0	45 =>		1.00																							
Irrigatable soils:																										
Y02LVEi2	15 =>			1.00																						
Y02LVEi1	0 =>																									
Y02LHii2	20 =>				1.00																					
Y02LHii1	0 =>																									
Irrigation permission:																										
Y02ir1	0 =>			-1.00										1.00												
Y02ir2	0 =>				-1.00										1.00											
Water supply:																										
Y02ws1i1	0 =>													-440.												
Y02ws1i2	0 =>													-200.												
Y02ws2i1	0 =>														-480.											
Y02ws2i2	0 =>														-200.											
Soil preparation inv.:																										
Y02Lim05	0 =>																									
Y02NtP05	0 =>																									
Y02ChP10	0 =>																									
Y02ChK10	0 =>																									
Y02CMi10	0 =>																									
Y02ChP05	0 =>																									
Y02ChK05	0 =>																									
Y02CMi05	0 =>																									
Y02CCa05	0 =>																									
Y02CSC05	0 =>																									
Y02CCe05	0 =>																									
Soil use ties:																										
Y02LVA0t	0 =>																									
Y02LVE0t	0 =>																									
Y02LHi0t	0 =>																									
Y02LVE1t	0 =>																									
Y02LHi1t	0 =>																									
Y02LVE2t	0 =>																									
Y02LHi2t	0 =>																									
Rotation possibilities:																										
Y02LLVA0	0 =>					-1.00																				
Y02CLVA0	0 =>						-1.00																			
Y02LLVE0	0 =>							-1.00																		
Y02CLVE0	0 =>								-1.00																	
Y02LLHI0	0 =>									-1.00																
Y02CLHI0	0 =>										-1.00															
Y02CLVE1	0 =>											-1.00														
Y02CLHI1	0 =>												-1.00													
Y02LLVE2	0 =>																									
Y02LLHI2	0 =>																									
Investments in assets:																										
Y02LT05a	0 =>																									
Y02LT05b	0 =>																									
Y02LT05c	0 =>																									
Family labour:																										
Y02FL05	200 =>																									
Y02FL06	200 =>																									
Y02FL07	200 =>																									

Sub-matrix TA7_1

	ACTIVITIES	TRANSFERS Soil inf. I01LVAi0	I01LVEi0	I01LVEi2	I01LHii2	Rotation Ir0101	Ir0102	Ir0103	Ir0104	Ir0105	Ir0106	Ir0107	Ir0108	Irrigation Isi01s1	Isi01s2	Tractor Ist01t1	Overdraft Iob0205	Iob0206	Mortgage Im01a02	Im01b02	Im01c02	Asset Ia104A	Production R01Y0205	S01Y0205	Farm cash I01fc	Farm defic I01fd
CONSTRAINTS																										
Family labour:																										
Y02FL08	200 =>																									
Y02FL09	200 =>																									
Y02FL10	200 =>																									
Y02FL11	200 =>																									
Y02FL12	100 =>																									
Y02FL01	200 =>																									
Y02FL02	200 =>																									
Y02FL03	200 =>																									
Y02FL04	200 =>																									
Employed tractor driver:																										
Y02TDPer	0 =>															-1.00										
Employed driver hours:																										
Y02EL05	0 =>																									
Y02EL06	0 =>																									
Y02EL07	0 =>																									
Y02EL08	0 =>																									
Y02EL09	0 =>																									
Y02EL10	0 =>																									
Y02EL11	0 =>																									
Y02EL12	0 =>																									
Y02EL01	0 =>																									
Y02EL02	0 =>																									
Y02EL03	0 =>																									
Y02EL04	0 =>																									
Seasonal labour:																										
Y02SL05	0 =>																									
Y02SL10	0 =>																									
Y02SL11	0 =>																									
Y02SL01	0 =>																									
Y02SL03	0 =>																									
Y02SL04	0 =>																									
Available tractor hours:																										
Y02ST05	0 =>															-200.										
Y02ST07	0 =>															-200.										
Y02ST08	0 =>															-200.										
Y02ST09	0 =>															-200.										
Y02ST10	0 =>															-200.										
Y02ST11	0 =>															-200.										
Y02ST01	0 =>															-200.										
Y02ST03	0 =>															-200.										
Y02ST04	0 =>															-200.										
Tractor requirements:																										
Y02TR05	0 =>																									
Y02TR07	0 =>																									
Y02TR08	0 =>																									
Y02TR09	0 =>																									
Y02TR10	0 =>																									
Y02TR11	0 =>																									
Y02TR01	0 =>																									
Y02TR03	0 =>																									
Y02TR04	0 =>																									
Harvester requirements:																										
Y02HR05	0 =>																									
Y02HR09	0 =>																									

Sub-matrix TA8_1

ACTIVITIES		TRANSFERS Soil inf. I01LVAi0	I01LVEi0	I01LVEi2	I01LHi2	Rotation Ir0101	Ir0102	Ir0103	Ir0104	Ir0105	Ir0106	Ir0107	Ir0108	Irrigation Iis01s1	Iis01s2	Tractor Ist01t1	Overdraft Iob0205	Iob0206	Mortgage Im01a02	Im01b02	Im01c02	Asset Ia0104A	Production R01Y0205	S01Y0205	Farm cash I01fc	Farm defic I01fd
CONSTRAINTS																										
Harvester requirements:																										
Y02HR03	0 =>																									
Y02HR04	0 =>																									
Maintenance costs:																										
(family consumption)																										
Y02fc	1 =																									
(discretionary cons.)																										
Y02dc04	0 =>																									
(overhead costs)																										
Y02oc	1 =																									
Machine variable costs:																										
Y02MVC05	0 =>																									
Y02MVC07	0 =>																									
Y02MVC08	0 =>																									
Y02MVC09	0 =>																									
Y02MVC10	0 =>																									
Y02MVC11	0 =>																									
Y02MVC01	0 =>																									
Y02MVC03	0 =>																									
Y02MVC04	0 =>																									
Costs of direct inputs:																										
Y02CDI05	0 =>																									
Y02CDI07	0 =>																									
Y02CDI08	0 =>																									
Y02CDI09	0 =>																									
Y02CDI10	0 =>																									
Y02CDI11	0 =>																									
Y02CDI01	0 =>																									
Y02CDI03	0 =>																									
Y02CDI04	0 =>																									
Asset evaluation:																										
Y02AE04	0 =>																					-1.00				
Complementary inv.:																										
Y02CIN04	0 =>																									
Mortgage:																										
(plan A)																										
Y02MOA05	0 =>																		1.00							
Y02MOA06	0 =>																									
Y02MOA07	0 =>																									
Y02MOA08	0 =>																									
Y02MOA09	0 =>																									
Y02MOA10	0 =>																									
Y02MOA11	0 =>																									
Y02MOA12	0 =>																									
Y02MOA01	0 =>																									
Y02MOA02	0 =>																									
Y02MOA03	0 =>																									
Y02MOA04	0 =>																									
(plan B)																										
Y02MOB05	0 =>																			1.00						
Y02MOB06	0 =>																									
Y02MOB07	0 =>																									
Y02MOB08	0 =>																									
Y02MOB09	0 =>																									
Y02MOB10	0 =>																									
Y02MOB11	0 =>																									

Sub-matrix TA9_1

	ACTIVITIES	TRANSFERS Soil inf. I01LVAi0	I01LVEi0	I01LVEi2	I01LHii2	Rotation Ir0101	Ir0102	Ir0103	Ir0104	Ir0105	Ir0106	Ir0107	Ir0108	Irrigation Iis01s1	Iis01s2	Tractor Ist01t1	Overdraft Iob0205	Iob0206	Mortgage Im01a02	Im01b02	Im01c02	Asset Ia0104A	Production R01Y0205	S01Y0205	Farm cash I01fc	Farm defic I01fd
CONSTRAINTS																										
Mortgage:																										
(plan B)																										
Y02MOB12	0 =>																									
Y02MOB01	0 =>																									
Y02MOB02	0 =>																									
Y02MOB03	0 =>																									
Y02MOB04	0 =>																									
(plan C)																										
Y02MOC05	0 =>																				1.00					
Y02MOC06	0 =>																									
Y02MOC07	0 =>																									
Y02MOC08	0 =>																									
Y02MOC09	0 =>																									
Y02MOC10	0 =>																									
Y02MOC11	0 =>																									
Y02MOC12	0 =>																									
Y02MOC01	0 =>																									
Y02MOC02	0 =>																									
Y02MOC03	0 =>																									
Y02MOC04	0 =>																									
Working capital:																										
Y02WK05	0 =>																								-1.00	1.00
Y02WK06	0 =>																									
Y02WK07	0 =>																	0.98								
Y02WK08	0 =>																									
Y02WK09	0 =>																									
Y02WK10	0 =>																									
Y02WK11	0 =>																									
Y02WK12	0 =>																									
Y02WK01	0 =>																									
Y02WK02	0 =>																									
Y02WK03	0 =>																									
Y02WK04	0 =>																									
Overdraft (short term):																										
Y02OD05	0 =>																									
Y02OD06	0 =>																									
Y02OD07	0 =>																									
Y02OD08	0 =>																									
Y02OD09	0 =>																									
Y02OD10	0 =>																									
Y02OD11	0 =>																									
Y02OD12	0 =>																									
Y02OD01	0 =>																									
Y02OD02	0 =>																									
Y02OD03	0 =>																									
Y02OD04	0 =>																									
Long term investments:																										
(plan A)																										
Y02IA05	0 =>																									
Y02IA06	0 =>																									
Y02IA07	0 =>																									
Y02IA08	0 =>																									
Y02IA09	0 =>																									
Y02IA10	0 =>																									
Y02IA11	0 =>																									
Y02IA12	0 =>																									

Sub-matrix TA10_1

ACTIVITIES		TRANSFERS Soil inf. I01LVAi0	I01LVEi0	I01LVEi2	I01LHii2	Rotation Ir0101	Ir0102	Ir0103	Ir0104	Ir0105	Ir0106	Ir0107	Ir0108	Irrigation Iis01s1	Iis01s2	Tractor Ist01t1	Overdraft Iob0205	Iob0206	Mortgage Im01a02	Im01b02	Im01c02	Asset Ia0104A	Production R01Y0205	S01Y0205	Farm cash I01fc	Farm deficit I01fd
CONSTRAINTS																										
Long term investments:																										
(plan A)																										
Y02IA01	0 =>																									
Y02IA02	0 =>																									
Y02IA03	0 =>																									
Y02IA04	0 =>																									
(plan B)																										
Y02IB05	0 =>																									
Y02IB06	0 =>																									
Y02IB07	0 =>																									
Y02IB08	0 =>																									
Y02IB09	0 =>																									
Y02IB10	0 =>																									
Y02IB11	0 =>																									
Y02IB12	0 =>																									
Y02IB01	0 =>																									
Y02IB02	0 =>																									
Y02IB03	0 =>																									
Y02IB04	0 =>																									
(plan C)																										
Y02IC05	0 =>																									
Y02IC06	0 =>																									
Y02IC07	0 =>																									
Y02IC08	0 =>																									
Y02IC09	0 =>																									
Y02IC10	0 =>																									
Y02IC11	0 =>																									
Y02IC12	0 =>																									
Y02IC01	0 =>																									
Y02IC02	0 =>																									
Y02IC03	0 =>																									
Y02IC04	0 =>																									
Market capital:																										
Y02MK05	1000 =>																									
Y02MK06	1000 =>																									
Y02MK07	1000 =>																									
Y02MK08	1000 =>																									
Y02MK09	1000 =>																									
Y02MK10	1000 =>																									
Y02MK11	1000 =>																									
Y02MK12	1000 =>																									
Y02MK01	1000 =>																									
Y02MK02	1000 =>																									
Y02MK03	1000 =>																									
Y02MK04	1000 =>																									
Production for sale:																										
(irrig. supplied)																										
Y02W09	0 =>																									
(no irrigation)																										
Y02R05	0 =>																						-1.00			
Y02S05	0 =>																							-1.00		
Y02R03	0 =>																									
Y02R04	0 =>																									
Y02S04	0 =>																									
Y03M05	0 =>																									

Appendix 4 Crop Yield Distributions

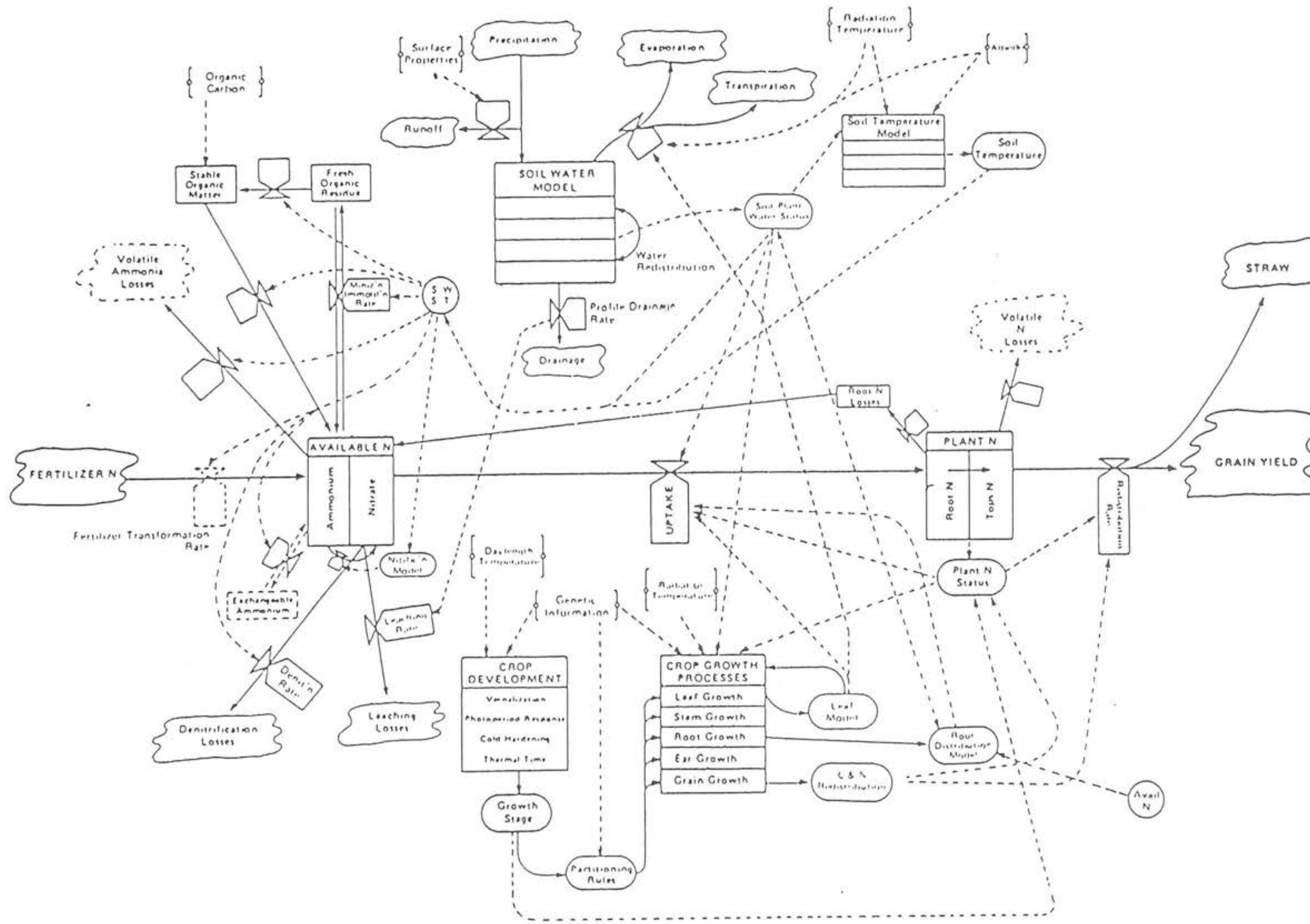


Figure A4.1 Systems Diagram of CERES-WHEAT -N: solid lines, material flows, dotted lines, information flows. Dotted lines enclosed items not described. SW = soil water, ST = soil temperature.
Source: Godwin and Vleck(1986) Simulation of nitrogen dynamics, in: Day, W. and Atkin, R. K.(1986) Wheat Growth and Modelling, Plenum Press, London, (pg 316).

Figure A4.2 SOYGRO-Soybean Simulation Model Output - File 01

SOYGRO V5.41
============

INPUT SUMMARY RUN NO. 1 SIMULATION BEGINS : APR 10

INST_ID: CP SITE_ID: AC EXPT_NO: 01 YEAR: 1986 TRT_NO: 1
EXPERIMENT : 'DOKO', IRRIGATED & LIMITED IRRIGATION
TREATMENT : Irrigated 'DOKO' Crop
WEATHER SET : Planaltina (15.5S,47.5E), BRAZIL 1986
VARIETY : DOKO MATURITY GROUP : 10
IRRIGATION : ACCORDING TO THE FIELD SCHEDULE
PLANTING DATE: MAY 6 PLANTS/M2: 25.00 ROW SPACING: .500m PLANT SPACING: .080m

SOIL PROFILE DATA Typic Haplustox (Dark Red Latossol)
SOIL ALBEDO : .14 U: 9.0 SWCON: .60 CURVE NO.: 60.0 PHFAC3:1.00

DEPTH-m	LL	DUL	SAT	EXTR	INIT	ROOT	KSAT
.00- .15	.205	.273	.660	.068	.265	.670	.000
.15- .30	.192	.268	.630	.076	.270	1.000	.000
.30- .45	.235	.309	.610	.074	.260	.530	.000
.45- .60	.223	.299	.630	.076	.260	.115	.000
.60- .75	.210	.282	.660	.072	.260	.045	.000
SUM mm	159.8	214.6	478.5	54.9	197.2		

RUN NO. 1 SIMULATION OUTPUT

CP AC 1986 Irrigated 'DOKO' Crop

DATE	CROP AGE	GROWTH STAGE	BIOMASS KG/HA	LAI	V-STAGE	WATER BALANCE COMPONENTS ES mm	EP mm	ET mm	RAIN mm	IRRIG mm	DROUGHT STRESS PHOTO	TURGOR
MAY 6	0	SOWING	0.	.00	.0	38.	0.	38.	82.	0.	.000	.000
MAY 13	7	EMERGENCE	16.	.02	.0	46.	0.	46.	85.	0.	.000	.000
MAY 21	15	UNIFOLIOL.	30.	.06	1.0	60.	0.	60.	103.	0.	.000	.027
JUN 2	27	END JUVEN.	112.	.28	3.4	80.	2.	82.	103.	53.	.000	.018
JUL 1	56	FLOWER IND	837.	1.48	8.6	117.	18.	136.	103.	240.	.000	.000
JUL 25	80	FLOWERING	2183.	3.22	13.0	132.	43.	175.	121.	443.	.000	.000
AUG 4	90	FIRST POD	2876.	3.81	15.0	136.	56.	192.	133.	532.	.000	.000
AUG 7	93	END LEAF	3042.	3.79	15.6	136.	59.	196.	133.	566.	.000	.000
AUG 11	97	FULL POD	3371.	3.78	15.6	138.	65.	203.	133.	616.	.000	.000
SEP 21	138	END POD	5896.	3.07	15.6	153.	118.	271.	170.	1011.	.000	.000
SEP 30	147	PHYS. MAT	6197.	2.76	15.6	157.	128.	285.	175.	1029.	.000	.000
OCT 12	159	HARV. MAT	4614.	.17	15.6	172.	137.	309.	213.	1029.	.000	.000

RUN NO. 1

CP AC 1986 Irrigated 'DOKO' Crop

	PREDICTED	MEASURED
FLOWERING DATE	206	201
FIRST POD	216	0
FULL POD	223	0
PHYSIOL. MATURITY	273	266
POD YLD (KG/HA)	2680.00	.00
SEED YLD (KG/HA)	1920.00	1871.00
SHELLING PERCENTAGE	71.64	.00
WT. PER SEED (G)	.121	.150
SEED NUMBER (SEED/M2)	1583.00	1517.00
SEEDS/POD	2.10	2.10
MAXIMUM LAI	3.81	7.40
BIOMASS (KG/HA) AT R8	4610.00	4286.00
STALK (KG/HA) AT R8	1840.00	1113.00
HARVEST INDEX	.416	.437

Irrigation Summary
==================

37 IRRIGATION APPLICATIONS @ .80 EFFICIENCY.

CROP AGE	42	46	49	53	56	60	63	67	70	73	76	80	83
AMOUNT,mm	11.	16.	12.	15.	17.	27.	19.	26.	20.	28.	20.	32.	24.

CROP AGE	87	90	94	97	100	104	108	111	114	117	120	124	128
AMOUNT,mm	36.	30.	36.	32.	42.	4.	26.	33.	30.	34.	50.	35.	47.

CROP AGE	131	135	138	142	145	149	152	157	159	163	166
AMOUNT,mm	39.	21.	28.	44.	32.	46.	37.	16.	18.	33.	17.

SOYBEAN YIELD : 1920.0 KG/HA [28.6 BU/ACRE]

RUN NO. 1 INPUT AND OUTPUT SUMMARY

INST_ID :CP SITE_ID: AC EXPT_NO: 01 YEAR : 1986 TRT_NO: 1
EXP. :CUIABANA RICE, GYPSUM USE STUDY, Non-irr
TRT. :1986 CUIABANA Upland (Gipsum use)no irr.
WEATHER :CPAC 1986 UPLAND DATA
SOIL :Typic Haplustox (Dark Red Latossol_2)
VARIETY :CUIABANA

LATITUDE OF EXPT. SITE = 15.5 degrees

PLANT POPULATION = 80.00 plants per sq. meter

SOWING DEPTH = 5.0 cm.

GENETIC SPECIFIC CONSTANTS P1 = 600.00 P2R = 120.00 P5= 450.00
P2O = 12.3 G1 = 3.200 TR = .900

IRRIGATION SCHEDULE

JUL DAY	IRRIGATION (mm.)
	(No irrigation applied.)

SOIL PROFILE DATA [PEDON: CPAC PEDON]
SOIL ALBEDO = .14
UPPER LIMIT OF SOIL EVAPORATION = 9.0
SOIL WATER DRAINAGE CONSTANT = .60
SCS RUNOFF CURVE NO.= 60.0

DEPTH OF LAYER-cm	LOWER LIMIT	UPPER LIMIT	SAT. CONTENT	EXTR. WATER	WATER CONTENT	ROOT FACTOR	SOIL NO3*	SOIL NH4*
0.- 15.	.205	.273	.660	.068	.165	1.000	2.5	.5
15.- 30.	.192	.268	.630	.076	.170	.900	.7	.5
30.- 45.	.235	.309	.610	.074	.160	.500	.6	.5
45.- 60.	.223	.299	.630	.076	.160	.070	.6	.5
60.- 75.	.210	.282	.660	.072	.160	.020	.6	.5
TOTAL 0.- 75.	16.0	21.5	47.9	5.5	12.2		7.	4.

* NOTE: Units are in kg N / ha.

FERTILIZER INPUTS

JUL DAY	KG/HA	DEPTH	SOURCE
350	20.00	20.00	AMMONIUM NITRATE

OUTPUT SUMMARY

DATE	JUL DAY	PHENOLOGICAL STAGE	TILLER NO.	BIOMASS	ROOT WT.	LEAF WT.	STEM WT.	PANICLE WT.	LAI
				(- - - grams per sq. meter - - - -)					
12/10/86	344	SOWING	0.						
12/14/86	348	GERMINATION	0.						
12/16/86	350	EMERGENCE	77.	.0	.0	.0	.0	.0	.0
1/26/87	26	END JUVENILE STAGE	3051.	16.6	3.4	16.4	.1	.0	.3
2/ 4/87	35	FLORAL INITIATION	3681.	37.1	8.5	34.8	2.3	.0	.6
3/16/87	75	HEADING	4753.	189.0	26.0	75.8	67.9	45.3	1.3
3/27/87	86	START GRAIN FILL	4710.	238.2	30.7	72.4	88.1	77.7	1.3
4/14/87	104	END GRAIN FILL	4421.	334.3	28.0	52.7	82.1	199.6	1.1
4/15/87	105	PHYSIOLOGICAL MATURITY	211.	334.3	28.0	52.7	82.1	199.6	1.1

COMPARISON BETWEEN PREDICTED AND FIELD-MEASURED DATA

	PREDICTED	OBSERVED
HEADING DATE (DAY OF YEAR)	75	77
MATURITY DATE (DAY OF YEAR)	105	112
GRAIN YIELD (MT/HA)	1.8	2.5
1,000 GRAIN WEIGHT (G)	21.85	.00
NO. PANICLES PER SQ. METER	211.	204.
PANICLE WEIGHT (KG/HA)	1996.	2670.
PANICLE-STRAW RATIO	1.29	.60
LAI AT HEADING	1.33	3.20
BIOMASS (KG/HA)	3343.2	6812.0
STRAW (KG/HA)	1547.2	4194.0

```
RUN    1 OUTPUT SUMMARY
INST_ID :CP  SITE_ID: AC  EXPT_NO: 01  YEAR : 1984  TRT_NO:  1
EXP.    :Summer Maize, CMS36 Non Irrigated
TRT.    :CMS36 ( Gypsum and N use study )
WEATHER :(Principal station) Brazil
SOIL    :Typic Haplustox ( Dark Red Latossol_2)
VARIETY :CMS36(EMBRAPA)
IRRIG.  :NEVER IRRIGATED, RAINFED.

LATITUDE =15.5, SOWING DEPTH =  5. CM, PLANT POPULATION =  6.3 PLANTS / SQ METER

GENETIC SPECIFIC CONSTANTS    P1 =214.00  P2 = .54  P5=860.00
                              G2 =800.00  G3 = 7.500


     SOIL PROFILE DATA [ PEDON: CPAC PEDON    ]
     SOIL ALBEDO=  .14  U=  9.0  SWCON=   .60   RUNOFF CURVE NO.=  60.0


 DEPTH-CM      LO LIM UP LIM  SAT SW EXT SW  IN SW    WR     NO3     NH4
                                                            ---mg/kg---
   0.-  15.     .205   .273   .660   .068   .265  1.000    2.5      .5
  15.-  30.     .192   .268   .630   .076   .270   .950     .7      .5
  30.-  45.     .235   .309   .610   .074   .260   .700     .6      .5
  45.-  60.     .223   .299   .630   .076   .260   .355     .6      .5
  60.-  75.     .210   .282   .660   .072   .260   .100     .6      .5

 T 0.-  75.     16.0   21.5   47.9    5.5   19.7             7.*     4.*

 * NOTE: Units are in kg / hectare.

FERTILIZER INPUTS
DAY OF YEAR     KG/HA      DEPTH   SOURCE

      312      20.00      12.50   UREA
       13      80.00        .00   UREA

          THE PROGRAM STARTED ON, 301 DAY OF YEAR


 DATE  CDTT PHENOLOGICAL STAGE          BIOM    LAI NUPTK   N%    CET  RAIN  PESW
 8 Nov    0. SOWING                     g/m^2       kg/ha          ---mm----   cm
10 Nov   28. GERMINATION                                            14.    5.    3.
14 Nov   54. EMERGENCE                                               7.   41.    6.
30 Nov  273. END JUVENILE                11.    .24    3.3  2.91   33.  135.    9.
 4 Dec  328. TASSEL INITIATION           18.    .37    4.8  2.61   41.  158.    7.
12 Jan  891. 75% SILKING                281.   2.10   25.7   .91  112.  570.    9.
25 Jan 1060. BEGIN GRAIN FILL           377.   1.91   55.9  2.13  131.  745.    8.
10 Mar 1699. END GRAIN FILL             715.    .86   21.0   .83  209. 1054.    6.
13 Mar 1744. PHYSIOLOGICAL MATURITY     715.    .86   21.0   .83  213. 1121.   10.

YIELD (KG/HA)=  4125. (BU/ACRE)= 65.7 FINAL GPSM= 1126. KERNEL WT.(mg)=309.6

ISTAGE        CSD1       CSD2      CNSD1       CNSD2   S T A G E  OF  G R O W T H
     1         .00        .00        .06         .19   EMERG to END JUVENILE PHASE
     2         .00        .00        .15         .41   END JUV to TASSEL INITIATION
     3         .00        .00        .24         .51   TASSEL INITIATION to SILKING
     4         .00        .00        .08         .20   SILKING to BEGIN GRAIN FILL
     5         .00        .00        .01         .08   GRAIN FILLING PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD), respectively.

                              PREDICTED      OBSERVED
SILKING DATE                      12            10
MATURITY DATE                     72            73
GRAIN YIELD (KG/HA)            4125.         4056.
KERNEL WEIGHT (G)               .310          .190
GRAINS PER SQ METRE            1126.         2967.
GRAINS PER EAR                180.17        464.00
MAX. LAI                        2.10          3.60
BIOMASS (KG/HA)                7148.        12241.
STRAW  (KG/HA)                 3662.         1460.
GRAIN N%                        1.66           .00
TOT N UPTAKE (KG N/HA)          78.9            .0
STRAW N UPTAKE                  21.0            .0
GRAIN N UPTAKE                  58.0            .0
```

```
RUN    1 OUTPUT SUMMARY


INST_ID :CP  SITE_ID: AC  EXPT_NO: 01  YEAR : 1986  TRT_NO:  1
EXP.    : Experiment ANUHUAC and BR-12(ARUANA)
TRT.    :April 28 ANAHUAC     auto irrigation
WEATHER :Principal station
SOIL    :Typic Haplustox ( Dark Red Latossol )
VARIETY :ANAHUAC (CPAC)
 IRRIGATED TO DUL IF EXTRACTABLE WATER IN TOP   .30m DROPS BELOW   80.0 %

LATITUDE= 15.5, SOWING DEPTH=  5. CM, PLANT POPULATION=400. PLANTS PER SQ METER

GENETIC SPECIFIC CONSTANTS    P1V = 2.5  P1D = 4.7  P5 = 6.0
                               G1 = 6.0   G2 = 4.4  G3 = 1.9


     DAY OF YEAR     IRRIGATION(MM)

     SOIL PROFILE DATA [ PEDON: CPAC PEDON    ]
     SOIL ALBEDO=  .14  U=  9.0  SWCON=   .60   RUNOFF CURVE NO.=  60.0

 DEPTH-CM      LO LIM UP LIM  SAT SW EXT SW  IN SW    WR    NO3    NH4
                                                            ---mg/kg---
   0.-  15.     .205   .273   .660   .068   .335  1.000   10.5     1.5
  15.-  30.     .192   .268   .630   .076   .340   .900    2.7     1.5
  30.-  45.     .235   .309   .610   .074   .330   .200    2.6     1.5
  45.-  60.     .223   .299   .630   .076   .330   .005    2.6     1.5
  60.-  75.     .210   .282   .660   .072   .330   .005    2.6     1.5

 T 0.-  75.     16.0   21.5   47.9    5.5   25.0            31.*    11.*

 * NOTE: Units are in kg / hectare.

FERTILIZER INPUTS
DAY OF YEAR    KG/HA     DEPTH    SOURCE

      112      17.20      5.00   POTASSIUM NITRATE
      139      40.00     15.00   AMMONIUM SULPHATE

         THE PROGRAM STARTED ON DAY   101

DATE  CDTT PHENOLOGICAL STAGE         BIOM    LAI NUPTK   N%    CET  RAIN  PESW
22 Apr    0. SOWING                   g/m^2        kg/ha         ----mm-----   cm
23 Apr   22. GERMINATION                                          27.   22.    6.
28 Apr  107. EMERGENCE                                             8.   21.    5.
 1 Jul 1426. T SPKLT VE DAYS= 0.       218.  1.80  86.7  3.98  133.  176.    4.
16 Jul 1718. END VEG BEGIN EAR GROWTH  350.  2.43  97.7  2.79  158.  209.    5.
25 Jul 1902. END EAR GR. EARS= 400.    439.  2.29  95.8  2.18  177.  237.    6.
 4 Aug 2110. BEG GR FILL               530.  2.01  95.0  1.79  197.  249.    5.
29 Aug 2653. MATURITY                  696.   .05  23.0   .58  247.  305.    4.

YIELD (KG/HA)=2974. (BU/ACRE)= 44.4 FINAL GPSM= 8515. KERNEL WT.(mg)= 34.9

ISTAGE      CSD1      CSD2      CNSD1      CNSD2   STAGE OF GROWTH
    1        .00       .00        .03        .17   EMERG -  TERM SPIKLT
    2        .00       .00        .00        .29   END VEG - BEGIN EAR GROWTH
    3        .00       .00        .00        .02   BEGIN EAR - END EAR GROWTH
    4        .00       .00        .00        .00   END EAR GRTH - BEGIN GRFIL
    5        .00       .00        .00        .00   LINEAR GRAIN FILL PHASE
* NOTE: In the above table, 0.0 represents minimum
   stress and 1.0 represents maximum stress for water (CSD)
   and nitrogen (CNSD) respectively,

                             PREDICTED     OBSERVED
ANTHESIS DATE                    209          202
MATURITY DATE                    241          226
GRAIN YIELD (KG/HA)            2974.        3748.
KERNEL WEIGHT (MG)              34.9         29.7
GRAINS PER SQ METRE            8515.       14647.
GRAINS PER EAR                 21.29        32.00
MAX. LAI                        2.43          .00
BIOMASS (KG/HA)                6961.        9345.
STRAW  (KG/HA)                 3987.        5601.
GRAIN N%                        2.36          .00
TOT N UPTAKE (KG N/HA)          93.1           .0
STRAW N UPTAKE                  23.0           .0
GRAIN N UPTAKE                  70.1           .0
```

Figure A4.6 CPAC/EMBRAPA Station Crop Yield Distributions

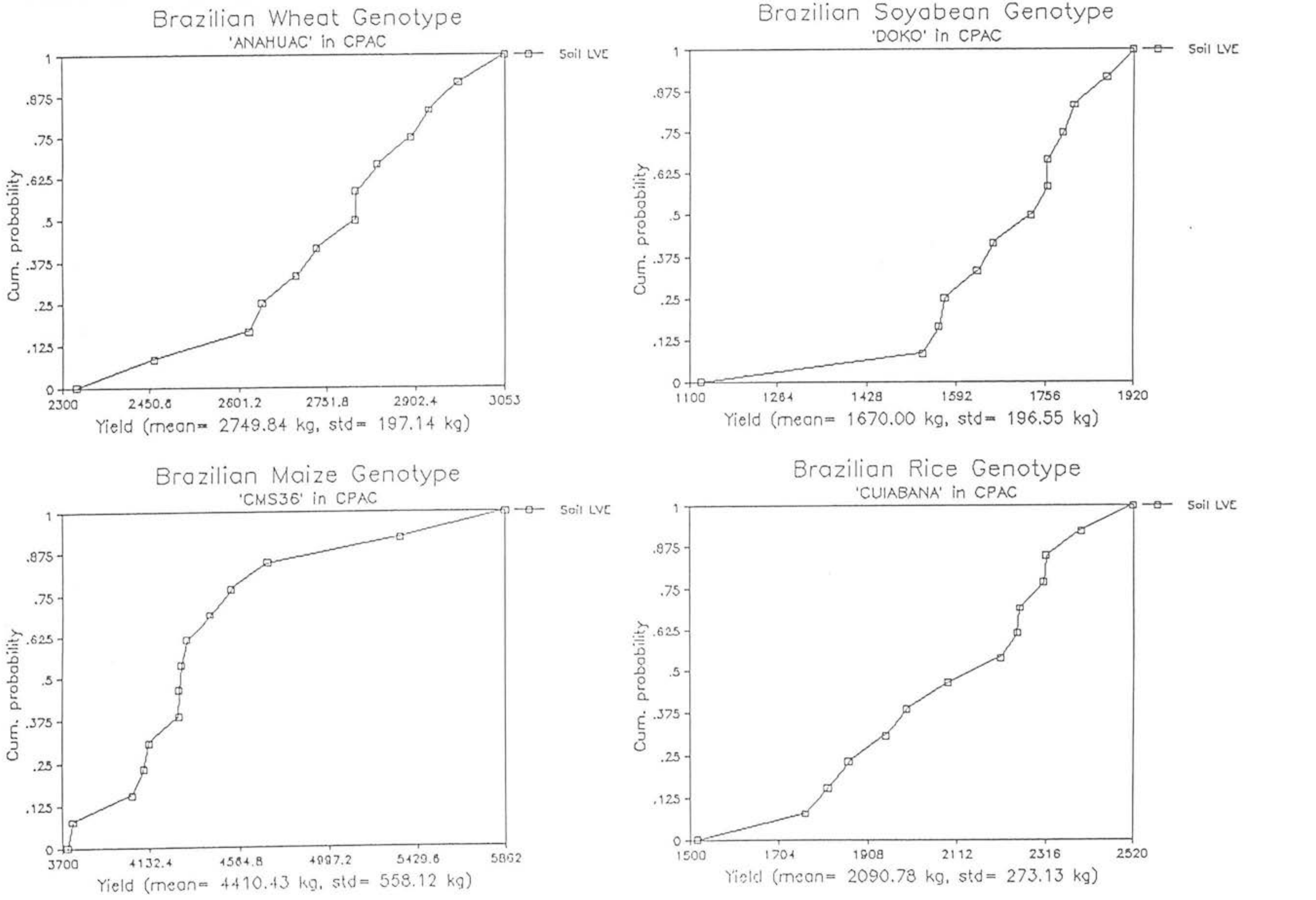
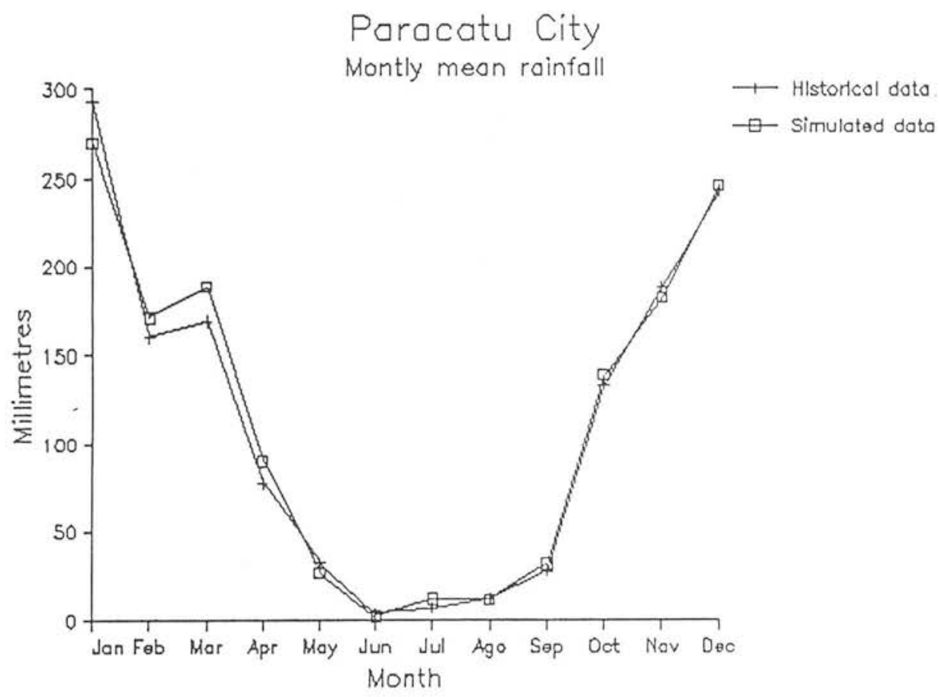
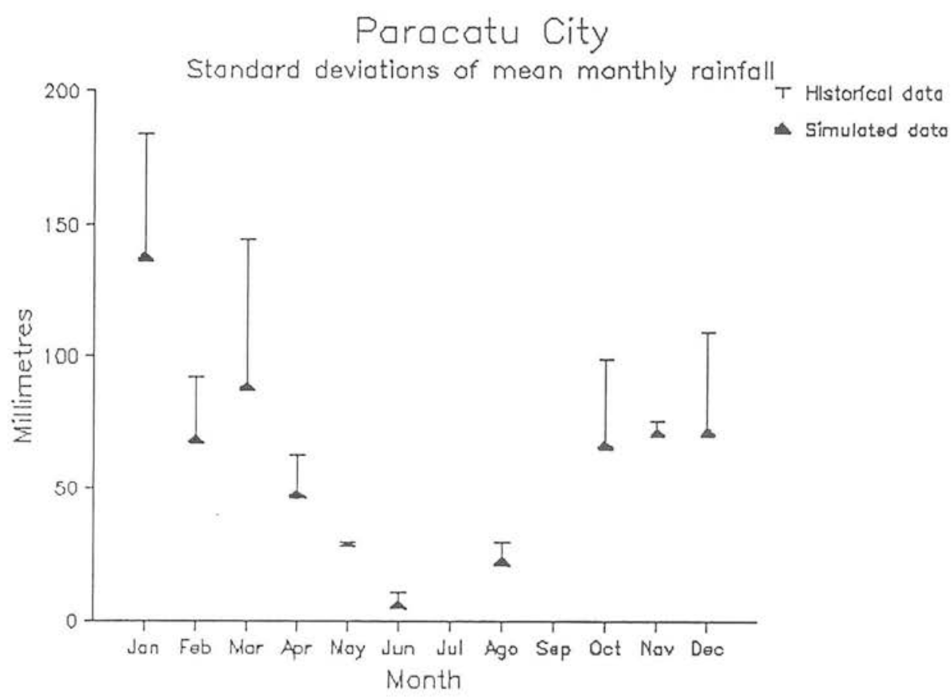


Figure A4.7 Historical and Simulated(*) Paracatu City Rainfall Data





(*) Simulated data by using WGEN simulation model.

Table A4.1 Simulated Crop Yield Distributions for Paracatu "Planicie" Conditions

	Rice			Wheat			Maize			No irrigated soya			Irrigated soya		
	lvec	lvac	lhic	lvew	lvaw	lhiw	lvem	lvam	lhim	nilve	nilva	nilhi	wilve	wilva	wilhi
								(kg/ha)							
	702	1093	1335	2672	2988	2917	3849	4409	4526	2160	2150	2160	2160	2150	2160
	1337	1139	1517	2441	2488	2374	4315	4174	4371	2250	2150	2280	2290	2220	2300
	872	700	1105	2939	3019	2999	4631	4595	4260	1830	1420	1960	2020	1770	2060
	1505	1445	1581	2631	2864	2724	4421	3821	5092	1890	1830	1910	1890	1830	1910
	1321	1033	1366	2479	2367	2366	3812	3057	4373	2200	2160	2210	2200	2160	2210
	1331	1216	1408	2612	2604	2610	3726	3138	4923	1930	1880	1930	1930	1910	1930
	1457	1355	1488	2580	2725	2776	4808	4843	4719	2170	2150	2170	2170	2150	2170
	1343	1299	1388	2617	2893	2657	4036	3230	4048	2060	2040	2070	2060	2040	2070
	910	433	1211	2227	2378	2223	4810	3822	4000	1930	1730	2020	2200	2150	2210
	1237	1042	1326	2747	2832	2704	4150	3584	4758	2280	2160	2290	2280	2160	2290
	1177	955	1236	2396	2365	2320	2707	2505	4127	1450	1010	1400	2230	2190	2240
	1089	1008	1194	2555	2555	2711	4589	4186	4731	2210	2130	2210	2210	2130	2210
	1193	1038	1234	2340	2455	2379	3354	3039	4021	2160	2000	2190	2160	2000	2190
	1040	912	1105	2369	2450	2429	4631	4259	4607	1670	1048	1750	1800	1370	1880
	1275	1117	1309	2160	2372	2318	4845	4799	4895	2260	2090	2290	2260	2090	2290
	1180	1018	1202	2301	2561	2372	5527	4630	5955	2040	1870	2090	2040	1870	2090
	1537	1208	1600	3080	3195	3130	3091	2837	4791	2130	2090	2140	2130	2090	2140
	1110	1029	1151	2678	2853	2772	2918	2568	4309	2040	2000	2040	2040	2000	2040
	1272	992	1328	2729	2782	2784	3625	2863	4253	2070	1860	2090	2070	1860	2090
	1100	897	1156	2618	2695	2704	3813	3095	5311	2210	2190	2210	2210	2190	2210
	1291	1106	1370	2042	2042	2113	3554	3045	4801	1840	1620	1880	1850	1640	1890
	1334	1182	1486	2510	2554	2537	4166	3397	4164	2240	2150	2280	2250	2170	2280
	1293	1146	1310	2329	2329	2337	3988	3546	4434	2030	2010	2030	2030	2010	2030
	1230	1021	1263	2916	2978	3001	3532	3518	4534	2250	2190	2260	2250	2190	2260
	1196	871	1340	2436	2588	2532	4231	4194	3649	1900	1340	2000	2150	1640	2220
	1275	1196	1339	2810	2912	2875	3786	2982	4170	2200	2130	2210	2200	2130	2210
	960	756	1076	1996	2441	2421	4433	3844	4809	1920	1800	1960	1950	1850	1960
	1225	1062	1275	2898	2996	2909	4441	3609	4617	2000	1990	2000	2000	1990	2000
	1229	1146	1274	2523	2705	2598	4529	4041	4837	2010	1980	2010	2010	1980	2010
	1300	1054	1332	2396	2371	2451	3096	3157	4693	2010	1900	2040	2010	1900	2040
	1418	1355	1510	2186	2184	2180	3629	3570	5076	2190	2070	2210	2190	2070	2210
mean	1217.29	1058.84	1316.61	2523.00	2630.36	2587.84	4033.65	3624.42	4575.94	2049.36	1907.68	2073.87	2104.52	1996.77	2122.58
std	179.71	197.56	135.15	258.79	272.33	260.06	630.40	648.18	446.88	185.91	311.70	182.54	130.55	194.78	125.62

Table A4.2 Statistical Results of Lilliefors Test on the Paracatu "Planicie" Crop Yield Distributions

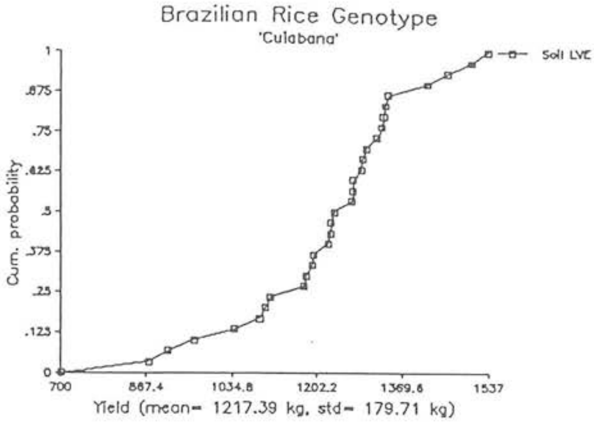
Crop	Soil type	Dmax
'Cuiabana'	LVEc	0.154
'Cuiabana'	LVAc	0.144
'Cuiabana'	LHic	0.110
'ANAHUAC'	LVEw	0.052
'ANAHUAC'	LVAw	0.092
'ANAHUAC'	LHiw	0.117
'CMS36'	LVEm	0.082
'CMS36'	LVAm	0.116
'CMS36'	LHim	0.093
Ni'Doko'	niLVE	0.140
Ni'Doko'	niLVA	0.203*
Ni'Doko'	niLHi	0.122
Wi'Doko'	wiLVE	0.150
Wi'Doko'	wiLVA	0.144
Wi'Doko'	wiLHi	0.173*

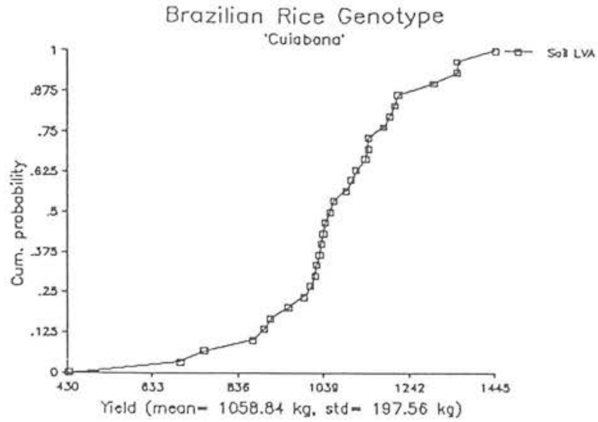
Source: STATGRAF Statistical Package, courtesy of Dr. Hughes, Edinburgh School of Agriculture.
*Statistics marked with an asterisk are significantly different from a normal distibution at the 5 % level.

Table A4.3 Correlation Matrix Between Different Crop Yield Distributions Estimated for Paracatu "Planicie" Conditions

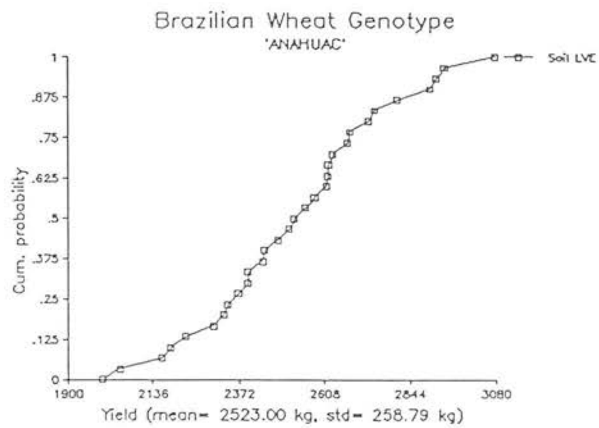
	Rice crop			Wheat crop			Maize crop			No irrig. Soya			Irrigated Soya		
	lvec	lvac	lhic	lvew	lvaw	lhiw	lvem	lvam	lhim	nilve	nilva	nilhi	wilve	wilva	wilhi
lvec	1.00														
lvac	.74	1.00													
lhic	.77	.74	1.00												
lvew	.10	.17	.17	1.00											
lvaw	-.04	.13	.06	.93	1.00										
lhiw	-.05	.13	.08	.91	.96	1.00									
lvem	-.19	-.16	-.16	-.20	-.10	-.02	1.00								
lvam	-.27	-.08	-.09	-.17	-.01	.01	.85	1.00							
lhim	.16	.27	.03	-.13	-.05	-.06	.32	.26	1.00						
nilve	.23	.32	.32	.22	.23	.21	.10	.11	.14	1.00					
nilva	.28	.43	.37	.24	.27	.26	.01	-.02	.24	.93	1.00				
nilhi	.17	.22	.28	.19	.21	.19	.19	.20	.11	.98	.86	1.00			
wilve	.04	-.04	.18	.15	.06	.07	-.08	.01	-.24	.59	.46	.56	1.00		
wilva	.13	.16	.27	.24	.16	.17	-.18	-.16	-.04	.59	.67	.49	.82	1.00	
wilhi	.03	-.07	.16	.11	.02	.02	-.05	.06	-.26	.56	.37	.55	.99	.73	1.00

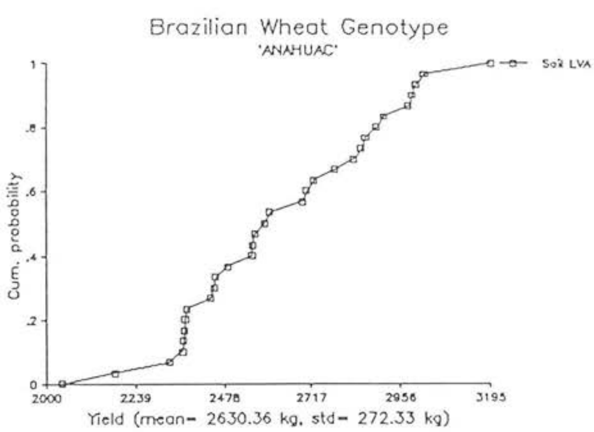
Source: STATGRAF Statistical Package, courtesy of Dr. Hughes, Edinburgh School of Agriculture.

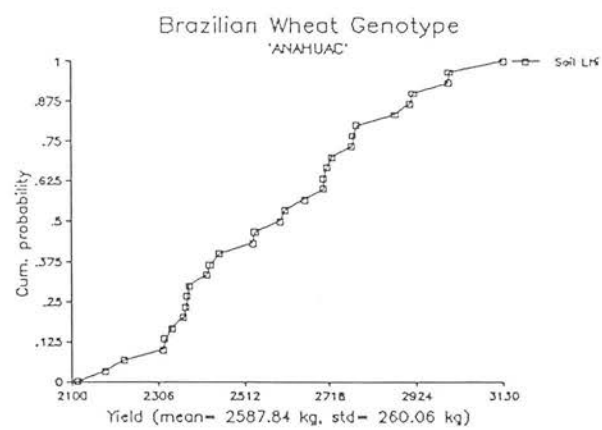

Brazilian Rice Genotype
'Culabana'
Soil LVE
Cum. probability
Yield (mean= 1217.39 kg, std= 179.71 kg)

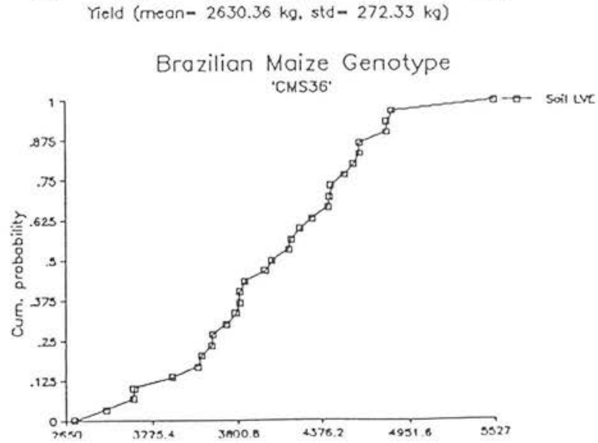

Brazilian Rice Genotype
'Culabana'
Soil LVA
Cum. probability
Yield (mean= 1058.84 kg, std= 197.56 kg)

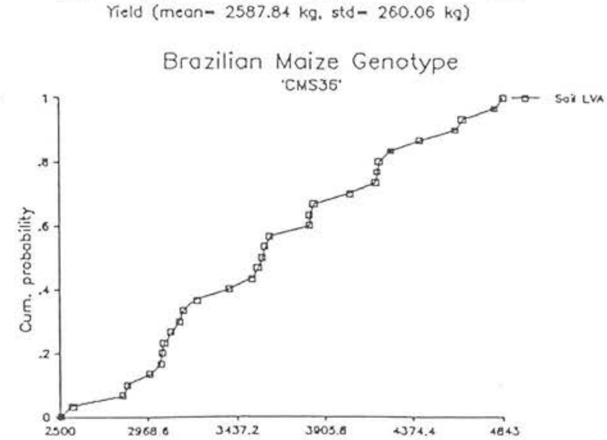

Brazilian Rice Genotype
'Culabana'
Soil LH
Cum. probability
Yield (mean= 1316.61 kg, std= 135.15 kg)

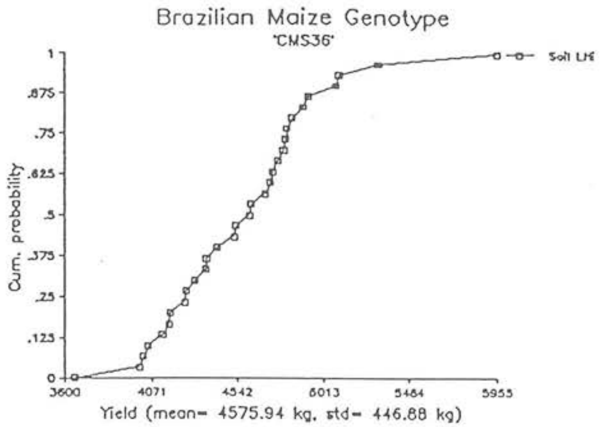

Brazilian Wheat Genotype
'ANAHUAC'
Soil LVE
Cum. probability
Yield (mean= 2523.00 kg, std= 258.79 kg)

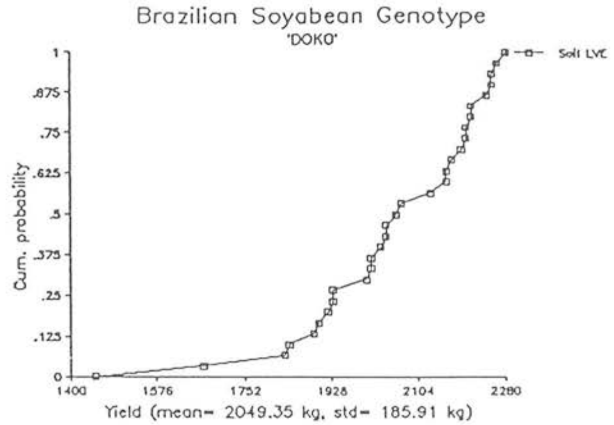

Brazilian Wheat Genotype
'ANAHUAC'
Soil LVA
Cum. probability
Yield (mean= 2630.36 kg, std= 272.33 kg)

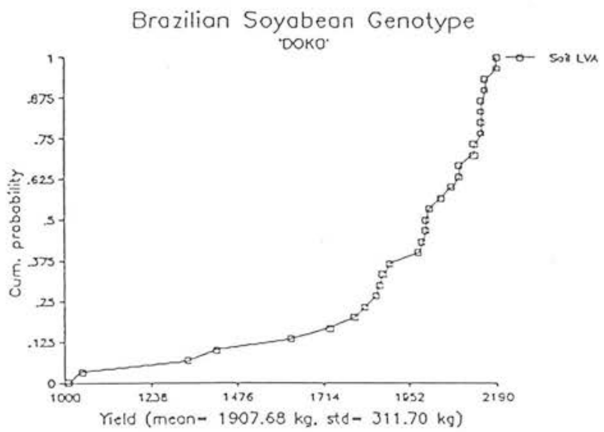

Brazilian Wheat Genotype
'ANAHUAC'
Soil LH
Cum. probability
Yield (mean= 2587.84 kg, std= 260.06 kg)

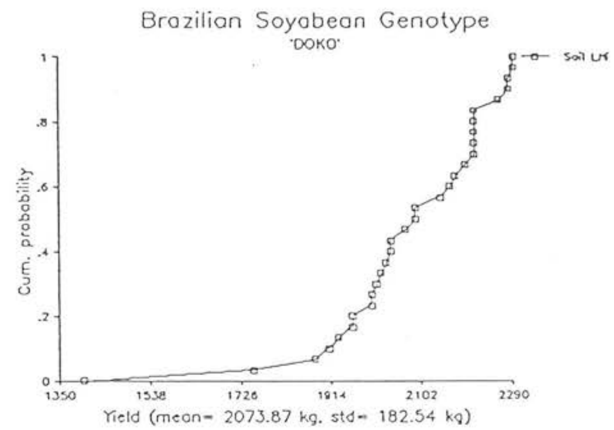

Brazilian Maize Genotype
'CMS36'
Soil LVE
Cum. probability

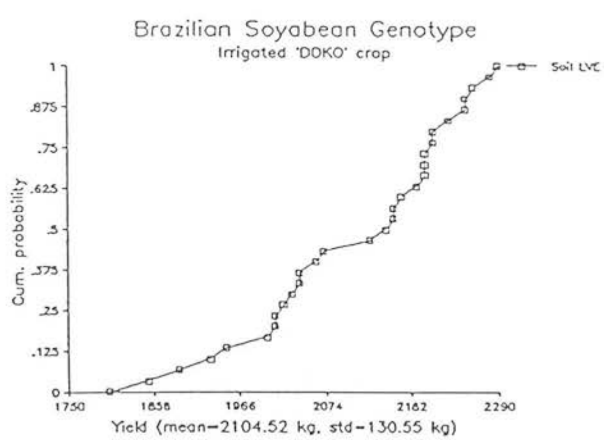

Brazilian Maize Genotype
'CMS36'
Soil LVA
Cum. probability

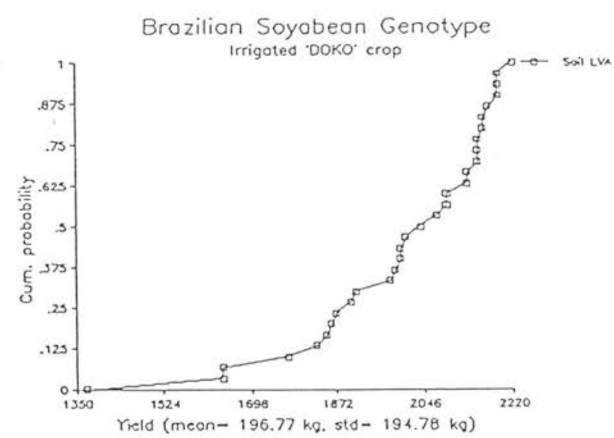

Brazilian Maize Genotype
'CMS36'
Soil LF
Cum. probability
Yield (mean= 4575.94 kg. std= 446.88 kg)

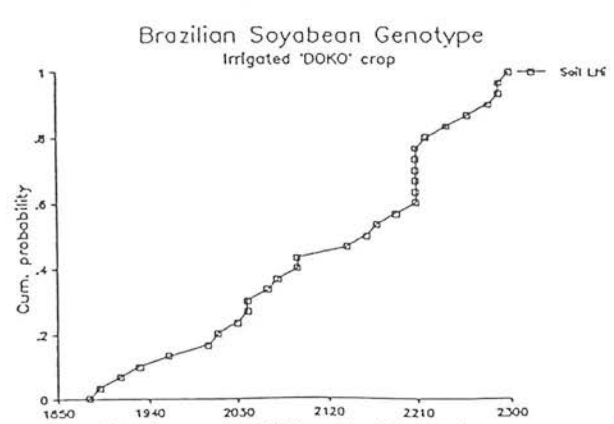

Brazilian Soyabean Genotype
'DOKO'
Soil LVE
Cum. probability
Yield (mean= 2049.35 kg. std= 185.91 kg)


Brazilian Soyabean Genotype
'DOKO'
Soil LVA
Cum. probability
Yield (mean= 1907.68 kg. std= 311.70 kg)


Brazilian Soyabean Genotype
'DOKO'
Soil LF
Cum. probability
Yield (mean= 2073.87 kg. std= 182.54 kg)


Brazilian Soyabean Genotype
Irrigated 'DOKO' crop
Soil LVE
Cum. probability
Yield (mean=2104.52 kg. std=130.55 kg)


Brazilian Soyabean Genotype
Irrigated 'DOKO' crop
Soil LVA
Cum. probability
Yield (mean= 196.77 kg. std= 194.78 kg)


Brazilian Soyabean Genotype
Irrigated 'DOKO' crop
Soil LF
Cum. probability
Yield (mean= 2122.58 kg. std= 125.62 kg)

```
c
c      This FORTRAN[1] program is used to prepare the standard and risk versions of the CECROPF
c       model
c
       PROGRAM MPS
       character c, r*12, a*36, ftype, land
       open(11,file='R1.doc',access='sequential',status='old')
       open(12,file='C1.doc',access='sequential',status='old')
       open(13,file='C2.doc',access='sequential',status='old')
       open(14,file='C3.doc',access='sequential',status='old')
       open(15,file='C4.doc',access='sequential',status='old')
       open(16,file='C5.doc',access='sequential',status='old')
       open(17,file='C6.doc',access='sequential',status='old')
       open(18,file='C7.doc',access='sequential',status='old')
       open(19,file='C8.doc',access='sequential',status='old')
c
   50  format (1x,'enter  S for MPS_sv    D for MOTAD')
   51  format (A1)
   52  format (1x,'invalid type S or D only')
   53  format (1x,'if you require LANDcost data included  Enter X')
  101  format(a1,a12)
  103  format(a12)
  102  format(a1,a36)
  104  format(a36)
c
 1000  write (6,50)
       read (5,51) ftype
       if (ftype .eq. 'S') then
        open(20,file='MPSTEST.DAT',access='sequential',status='new')
       elseif(ftype .eq. 'D') then
        open(20,file='MOTAD.DAT',access='sequential',status='new')
       else
          write (6,52)
          go to 1000
       endif
 2000  land = ' '
       write (6,53)
       read (5,51) land
       if (land .ne. 'X' .and. land .ne. ' ') go to 2000
 3000  read (11,101,end=4000)c,r
       if (c .eq. 'N' .or. c .eq. 'R' .or. c .eq. ' ') then
          write(20,101) c,r
       elseif (ftype .eq. 'S' .and. c .eq. 'S') then
          write(20,103) r
       elseif (ftype .eq. 'D' .and. c .eq. 'M') then
          write(20,103) r
       endif
       go to 3000
 4000  do 7000 i=1,8
 5000    read (i+11,102,end=7000)c,a
         if (c .eq. 'T' .and. land .eq. 'X') then
            go to 5000
         elseif (c .eq. 'C' .or. c .eq. ' ' .or. c .eq. 'R' .or.
     1           c .eq. 'E') then
            write (20,102) c,a
         elseif ((c .eq. 'S' .and. ftype .eq. 'S') .or.
     1          (c .eq. 'M' .and. ftype .eq. 'D')) then
            write (20,104) a
         elseif (c .eq. 'X' .and. land .eq. 'X') then
            write(20,104) a
         endif
         go to 5000
 7000  continue
c
       close (11)
       close (12)
       close (13)
       close (14)
       close (15)
       close (16)
       close (17)
       close (18)
       close (19)
       close (20)
       stop
       end
```

---

[1] Microsoft FORTRAN version 4.0

Appendix 6 Major Features of Farm Systems Generated by the CECROPF Model

A6.1 Introduction

Given the time required to generate and analyse a large number of alternative farm systems for the Paracatu "Planicie" area, this study has included a limited number of such farm systems. The CECROPF model generates an ample solution, but only major features of the farm systems projected by it are incorporated in the formulation of the GP model described in Chapter 7.

Eight major factors of the CECROPF model results are set in the GP model mentioned above (see Tables 7.2 and 7.3 in Chapter 7). They are estimated by accounting yearly basis results into single values as described below.

A6.2 Projected Farm Systems

Three projected farm systems generated by CECROPF model are considered for the development of the Paracatu "Planicie" area. For these projected farm systems, it is important to mention the following: the public capital required for development of such farm systems is lent at a subsidised[1] rate of 10.5 percent per year for crop maintenance credits and 13.2 percent per year for farm

[1]Interest rate based on 12 percent real interest rate on market capital.

asset investment credits. The reason why these subsidy rates were incorporated into CECROPF model is because they generate final farm net revenues (after 10 and a half years) that are appropriate (from the point of view of some Brazilian advisers) to motivate someone to undertake such projected farm systems. This perhaps could be better estimated by developing an extensive sensitivity analysis but the adopted procedure provide guidelines. Also, at regional level the eight features described below are considered enough to characterize the selected farm systems.

A6.2.1 Soil areas for cultivation and ecological reserve

The Paracatu "Planicie" area presents three different soil types (LVA, LVE and LHi) as described in the first rows of the GP model matrix. The projected land use follows the Brazilian land legislation: 80 percent of each farm system area is appropriate for cultivation and the remaining 20 percent is supposed to be an ecological reserve, (see Table 7.2 and Table A6.01).

A6.2.2 Public capital requirements for investments in soil preparation and machinery

Agricultural credit is available for soil preparation and machinery (first tractor and irrigation systems) investments. The rows R004 and R005 of the GP model matrix represent the public capital requirements for such investments of each selected farm system, (see Table 7.2).

A6.2.3 Total area cultivated with each alternative crop

The total areas of each crop (in the projected period of 10 and a half years) of each farm system are included in

Table A6.01: Soil Areas for Cultivation and Ecological Reserves of the Selected Farm Systems

	LVA soil		LVE soil		LHi soil		total soil area		
Farm syst.	reserve (ha)	crops (ha)	reserve (ha)	crops (ha)	reserve (ha)	crops (ha)	reserve (ha)	crops (ha)	total (ha)
Fs01	7.	20.	10.	60.	8.	20.	25.	100.	125.
Fs02	2.5	40.	20.	90.	15.	20.	37.5	150.	187.5
Fs03	5.	50.	5.	105.	33.75	20.	43.75	175.	218.75

Note: Such selected farm systems are projected by running the CECROPF model according to the Table A6.02. The last two digits of the above farm systems identification correspond to the run number of the Table A6.02.

the rows R007 to R009 because the important soil losses estimation depend on such parameters, (see Table 7.2).

A6.2.4 Hired labour

The seasonal (daily basis) and the contracted (monthly basis) labour forces required (in the projected period of 10 and a half years) are aggregated in the R011 as hired labour, (see Table 7.2).

A6.2.5 Discretionary consumption

The total discretionary consumption in the projected period of 10 and a half years, is estimated according to the cash surplus and final cash of each year. Twenty percent of the difference between annual cash surplus and annual final cash is selected as annual discretionary consumption. All annual discretionary consumption together forms the total discretionary consumption, (see R012, Table 7.2). Rather than adopt a single estimate for discretionary consumption a better approach would have been to carry-out sensitivy analysis: time however prevemted this approach.

A6.2.6 Initial own capital requirement

The initial own capital requirement is the farmer's capital amount (expressed in OTN) to start the crop farm business, (see R013, Table 7.2).

A6.2.7 Market capital

If it is necessary, the farmer use market capital at 2 percent (per month) real interest rate. The maximum market capital requirement of each selected farm system is specified in the R014 of the GP model matrix, (see Table 7.2).

A6.2.8 Farm business net revenue

The final result of CECROPF model standard version is the farm business net revenue (at the 10 percent discount rate). Following Dent et al(1986), the R015 of the GP model matrix includes a MOTAD target value which is below (here 70 percent of such a result is appropriate) the optimum solution of the CECROPF model standard model, (see Tables A6.02 and 7.2).

A6.3 Sub-matrix Showing Farm Systems Incorporated in the GP Model Matrix

The major features of the CECROPF model risk version results are summarized in the Tables A6.2 below and Table 7.2 (see Chapter 7). The yearly final cash and the available capital at the end of the farm planning period (determined by running the CECROPF model standard version), are basic data to set the CECROPF model MOTAD version.

The main financial results (which are the yearly final cash flow and the available capital at the end of the 10 and a half years) of the CECROPF model MOTAD version are set to correspond to 70 percent of the previous results, as mentioned above.

Table A6.02: Results of CECROPF Model Runs

Run[1]	Yearly final cash										AC1109[2] (OTN)	DTK[3] (OTN)
	I01fc (OTN)	I02fc (OTN)	I03fc (OTN)	I04fc (OTN)	I05fc (OTN)	I06fc (OTN)	I07fc (OTN)	I08fc (OTN)	I09fc (OTN)	I10fc (OTN)		
01sv	1888.41	34.06	647.36	2797.13	13.75	12.97	13.74	12.97	1297.41	616.72	15884.59	9021.74
01mo	1321.88	23.84	453.15	1957.99	9.62	9.07	9.61	9.07	907.18	431.70	11119.21	6315.20
02sv	1079.05	0.0	495.75	4086.68	13.22	12.10	13.22	12.10	1584.03	500.33	20421.95	12376.92
02mo	754.97	0.0	347.02	2860.67	9.25	8.47	9.25	8.47	1108.82	350.23	14295.36	8663.84
03sv	757.40	98.16	199.82	3667.45	15.55	15.27	15.55	15.27	1116.00	573.62	25547.00	15819.31
03mo	530.17	68.71	139.87	2567.21	10.88	10.68	10.88	10.68	781.20	401.53	17882.90	11073.52

[1]The identification sv means CECROPF model standard version results and mo means CECROPF model MOTAD version results.
[2]The AC1109 variable means the available capital at the end of the planning period.
[3]The DTK variable is the objective function of the CECROPF model standard version which means discounted (at 10 % discount rate) total capital.

Appendix 7 Results of the GP Model and its Extension

Figure A7.1 Input of the GP Model Run01b

```
STRT
  24   16    5   69    4    7    0
NAME
ALTERNATIVE CROP FARM SYSTEMS f                          03/12/90
RHS
          R001    37394.0 L     4 1.                                Soil LVA
          R002   112182.0 L     4 1.                                Soil LVE
          R003    37394.0 L     4 1.                                Soil LHi
          R004        0.0 E                                         Soil inv.
          R005        0.0 E                                         Mach. inv.
          R006        0.0 E                                         Total Credit
          R007        0.0 E                                         Rice crops
          R008        0.0 E                                         Maize crops
          R009        0.0 E                                         Soybean crops
          R010        0.0 E                                         Soil losses
          R011        0.0 E                                         Hired labour
          R012        0.0 E                                         Disc. consumpt.
          R013        0.0 E                                         Own capital
          R014        0.0 E                                         Market capital
          R015        0.0 E                                         Net revenue
          R016        0.0 E                                         Sel. farm syst.
          R017        0.0 G                           1 4.          Inv credit
          R018        0.0 G                           1 3.          Initial capital
          R019 99999999.0 L     3 1.                                Hired labour
          R020      637.0 G                           1 1.          Total disc. cons.
          R021 99999999.0 L     5 1.                                Number of farmers
          R022 99999999.0 L     1 1.                                Market capital
          R023 99999999.0 L     1 2.                                Regional income
          R024        0.0 G                           2 1.          Total soil losses
END
MTRX
      X014R001       27.0                                           Farm system 01
      X014R002       70.0
      X014R003       28.0
      X014R004    12.5998                                           (12599.8 OTN/1000)
      X014R005     7.0000                                           ( 7000.0 OTN/1000)
      X014R007     -157.3
      X014R008     -132.0
      X014R009     -620.1
      X014R011      5.069                                           (11151.8  hs/2200)
      X014R012       .477                                           (  477.0 OTN/1000)
      X014R013        2.5                                           ( 2500.0 OTN/1000)
      X014R014      .7359                                           (  735.9 OTN/1000)
      X014R015    -6.3152                                           ( 6315.2 OTN/1000)
      X014R016        1.0
      X015R001       42.5                                           Farm system 02
      X015R002      110.0
      X015R003       35.0
      X015R004    19.0506
      X015R005      7.000
      X015R007     -248.2
      X015R008     -219.0
      X015R009     -819.0
      X015R011     7.5899                                           (16697.84 hs/2200)
      X015R012      .4678
      X015R013        2.5
      X015R014        1.0                                           (market capital)
      X015R015    -8.6638                                           (net revenue)
      X015R016        1.0                                           (selec. farm syst.)
      X016R001       55.0                                           Farm system 03
      X016R002      110.0
      X016R003      53.75
      X016R004     22.363
      X016R005      7.000
      X016R007     -388.9
      X016R008     -291.9
      X016R009     -934.1
      X016R011      9.806
      X016R012      .3889
      X016R013        2.5
      X016R014        1.0                                           (market capital)
      X016R015   -11.0735                                           (net revenue)
      X016R016        1.0                                           (seleç. farm syst.)
      X001R004       -1.0                                           Inv. in soils
      X001R006        1.0
      X002R005       -1.0                                           Inv. in mach.
      X002R006        1.0
      X003R006       -1.0                                           Inv. total
      X003R017        1.0
      X004R007        1.0                                           Total area (rice)
      X004R010       -8.0
      X005R008        1.0                                           Total area (maize)
      X005R010      -29.0
      X006R009        1.0                                           Total area (soya)
      X006R010       -9.0
      X007R010        1.0                                           Total soil losses
      X007R024        1.0
      X008R013       -1.0                                           Initial capital
      X008R015        1.0
      X008R018        1.0
      X009R014       -1.0                                           Market capital
      X009R022        1.0
      X010R015        1.0                                           Generated capital
      X010R023        1.0
      X011R011       -1.0                                           Hired labour
      X011R019        1.0
      X012R012       -1.0                                           Disc. consumption
      X012R020        1.0
      X013R016       -1.0                                           Number of farms
      X013R021        1.0
END
SOLV
STOP
```

Figure A7.2 Output of the GP Model Base Run01b

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                         SUMMARY OF INPUT INFORMATION

              NUMBER OF CONSTRAINT ROWS..................  24
              NUMBER OF NON-ZERO MATRIX ENTRIES..........  80
              NUMBER OF VARIABLES(INCLUDING SLACK).......  27
              NUMBER OF PRIORITIES.......................   5
              NUMBER OF DECISION VARIABLES...............  16
              NUMBER OF POSITIVE DEVIATIONAL VARIABLES...   4
              NUMBER OF NEGATIVE DEVIATIONAL VARIABLES...   7
              NUMBER OF ARTIFICIAL VARIABLES.............  17
              NUMBER OF ITERATIONS TO FIND THE SOLUTION..   0

                      OPTIMAL VALUE OF DECISION VARIABLES
               VARIABLE          DESCRIPTION            AMOUNT
                X014        Farm system 01              1335.43
                X001        Inv. in soils              16826.15
                X002        Inv. in mach.               9348.01
                X003        Inv. total                 26174.16
                X004        Total area (rice)         210063.10
                X005        Total area (maize)        176276.70
                X006        Total area (soya)         828100.00
                X007        Total soil losses       14245430.00
                X008        Initial capital             3338.57
                X009        Market capital               982.74
                X010        Generated capital           5094.93
                X011        Hired labour                6769.29
                X012        Disc. consumption            637.00
                X013        Number of farms             1335.43

                          GOAL ACHIEVEMENT
GOAL LEVEL     1 IS NOT ACHIEVED IN THE FOLLOWING CONSTRAINTS-
       *      R017, Inv credit        ,                   IS OVERACHIEVED BY      26174.16 UNITS.
       *      R018, Initial capital   ,                   IS OVERACHIEVED BY       3338.57 UNITS.
       *      R022, Market capital    ,                   IS UNDERACHIEVED BY  99999020.00 UNITS.
       *      R023, Regional income   ,                   IS UNDERACHIEVED BY  99994900.00 UNITS.
       * SUMMARY-                GOAL      1 IS NOT ACHIEVED BY 300103600.00 WGTD UNITS.

GOAL LEVEL     2 IS NOT ACHIEVED IN THE FOLLOWING CONSTRAINTS-
       *      R024, Total soil losses ,                   IS OVERACHIEVED BY  14245430.00 UNITS.
       * SUMMARY-                GOAL      2 IS NOT ACHIEVED BY  14245430.00 WGTD UNITS.

GOAL LEVEL     3 IS NOT ACHIEVED IN THE FOLLOWING CONSTRAINTS-
       *      R019, Hired labour      ,                   IS UNDERACHIEVED BY  99993230.00 UNITS.
       * SUMMARY-                GOAL      3 IS NOT ACHIEVED BY  99993230.00 WGTD UNITS.

GOAL LEVEL     4 IS NOT ACHIEVED IN THE FOLLOWING CONSTRAINTS-
       *      R001, Soil LVA          ,                   IS UNDERACHIEVED BY      1337.40 UNITS.
       *      R002, Soil LVE          ,                   IS UNDERACHIEVED BY     18701.91 UNITS.
       *      R003, Soil LHi          ,                   IS UNDERACHIEVED BY         1.97 UNITS.
       * SUMMARY-                GOAL      4 IS NOT ACHIEVED BY     20041.27 WGTD UNITS.

GOAL LEVEL     5 IS NOT ACHIEVED IN THE FOLLOWING CONSTRAINTS-
       *      R021, Number of farmers ,                   IS UNDERACHIEVED BY  99998660.00 UNITS.
       * SUMMARY-                GOAL      5 IS NOT ACHIEVED BY  99998660.00 WGTD UNITS.

                          GOAL SLACK ANALYSIS
 *ALL GOALS WITH CONSTRAINT TYPE -B- WERE EITHER UNATTAINED AND
 TREATED IN THE GOAL ATTAINMENT SECTION, OR THE GOALS WERE MET AT
  THEIR SPECIFIED LEVEL. THEREFORE THIS SECTION OFANALYSIS IS NOT
 NEEDED.**

                          RESOURCE UTILIZATION ANALYSIS
      ***ALL RESOURCES, AS EXPRESSED IN CONSTRAINTS, WERE USED***
STOP
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Table A7.01: Soil Areas for Cultivation and Ecological Reserves of Alternative Farm Systems of an Extended GP Model

	LVA soil		LVE soil		LHi soil		total soil area		
Farm syst.	reserve (ha)	crops (ha)	reserve (ha)	crops (ha)	reserve (ha)	crops (ha)	reserve (ha)	crops (ha)	total (ha)
Fs01	7.	20.	10.	60.	8.	20.	25.	100.	125.
Fs02	2.5	40.	20.	90.	15.	20.	37.5	150.	187.5
Fs03	5.	50.	5.	105.	33.75	20.	43.75	175.	218.75
Fs04	3.	20.	18.	60.	4.	20.	25.	100.	125.
Fs05	2.	40.	30.5	90.	5.	20.	37.5	150.	187.5
Fs06	5.	50.	35.	105.	3.75	20.	43.75	175.	218.75
Fs07	2.	20.	20.	60.	3.	20.	25.	100.	125.
Fs08	1.5	40.	33.	90.	3.	20.	37.5	150.	187.5
Fs09	2.	50.	39.75	105.	2	20.	43.75	175.	218.75

Note: These alternative farm systems above are projected by running the CECROPF model according to the following:
Fs01, Fs04 and Fs07 relate to the runs 01sv and 01mo of the Table A6.02 of the Appendix 6.
Fs02, Fs05 and Fs08 relate to the runs 02sv and 02mo of the Table A6.02 of the Appendix 6.
Fs03, Fs06 and Fs09 relate to the runs 03sv and 03mo of the Table A6.02 of the Appendix 6.

Table A7.2 Goal Attainment Levels and Priority and Weight Attributes Used in Extended GP Model Runs (effects of changing goal priorities).

goal description	goal level	(unit)	goal type	deviation allowed	priority and weight attributes(1) run 11	run 12	run 13	run 14
Soil LVA	37394.0	ha	max	under	4 (1)	2 (1)	2 (1)	3 (1)
Soil LVE	112182.0	ha	max	under	4 (1)	2 (1)	2 (1)	3 (1)
Soil LHi	37394.0	ha	max	under	4 (1)	2 (1)	2 (1)	3 (1)
Inv credit	0.0	1000 OTN	min	over	1 (4)	5 (4)	1 (4)	2 (4)
Initial capital	0.0	1000 OTN	min	over	1 (3)	5 (3)	1 (3)	2 (3)
Hired labour	99999999.0	1 man year	max	under	3 (1)	3 (1)	5 (1)	4 (1)
Total disc. cons.	707.8	1000 OTN	min	over	1 (1)	5 (1)	1 (1)	2 (1)
Number of farmers	99999999.0	farms	max	under	5 (1)	1 (1)	3 (1)	1 (1)
Market capital	99999999.0	1000 OTN	max	under	1 (1)	5 (1)	1 (1)	2 (1)
Regional income	99999999.0	1000 OTN	max	under	1 (2)	5 (2)	1 (2)	2 (2)
Total soil losses	0.0	t	min	over	2 (1)	4 (1)	4 (1)	5 (1)
Max ir. area - LVE soil	26000.0(2)	ha	max	under	4 (2)	2 (2)	2 (2)	3 (2)
Max ir. area - LHi soil	34000.0(2)	ha	max	under	4 (2)	2 (2)	2 (2)	3 (2)

(1) Values in brackets are the differential weights associated with the priority levels.
(2) Up to 1700 farming systems were allowed.

Table A7.3 Optimal Value of Decision Variables of Extended GP Model Runs (effect of changing goal priorities).

Variable	description	(unit)	run 11 amount	run 12 amount	run 13 amount	run 14 amount
X014	Farm system 01	number	652.66	652.91	652.66	445.17
X017	Farm system 04	number	0.00	0.00	0.00	1038.72
X020	Farm system 07	number	831.20	830.98	831.20	0.00
X001	Inv. in soils	1000 OTN	18696.31	18696.70	18696.31	18696.70
X002	Inv. in mach.	1000 OTN	10387.00	10387.22	10387.00	10387.22
X003	Inv. total	1000 OTN	29083.31	29083.93	29083.31	29083.93
X004	Total area (rice)	ha	233410.80	233415.70	233410.80	233415.70
X005	Total area (maize)	ha	195869.20	195873.30	195869.20	195873.30
X006	Total area (soya)	ha	920139.90	920159.50	920139.90	920159.50
X007	Total soil losses	t	15828750.00	15829090.00	15828750.00	15829090.00
X008	Initial capital	1000 OTN	3709.64	3709.72	3709.64	3709.72
X009	Market capital	1000 OTN	1091.97	1091.99	1091.97	1091.99
X010	Generated capital	1000 OTN	5661.21	5661.33	5661.21	5661.33
X011	Hired labour	1 man year	7521.67	7521.83	7521.67	7521.83
X012	Disc. consumption	1000 OTN	707.80	707.82	707.80	707.82
X013	Number of farms	number	1483.86	1483.89	1483.86	1483.89